

SURVEY ON OKINAWA RAIL
AT JUNGLE WARFARE TRAINING CENTER,
MCB CAMP SMEDLEY D. BUTLER
OKINAWA, JAPAN



FINAL REPORT

Contract Number: M67400-09-P-0223

Prepared for: Marine Corps Base Camp Smedley D. Butler

Facilities Engineer Division Environmental Branch

May 2010



Prepared by: Nansei Environmental Laboratory Co., Ltd

EXECUTIVE SUMMARY

Survey on Okinawa Rail at Jungle Warfare Training Center MCB CAMP SMEDLEY D. BUTLER OKINAWA, JAPAN

Prepared for: MCB Camp Smedley D. Butler Facilities Engineer Environmental Branch

Prepared by: Nansei Environmental Laboratory Co., Ltd



The goal of this survey is to: 1) reveal the current distribution of the Okinawa Rail in the Jungle Warfare Training Center (JWTC), 2) compare the current distribution to the previous distribution surveyed in 2004, and 3) evaluate the actions taken to manage and protect the rail in the future.

Okinawa Rail (*Rallus Okinawae*), a bird species endemic to northern Okinawa Island, is a nearly flightless bird. The rail, which is 360 mm in length with a wingspan of 500 mm, is designated as a National Natural Monument and a National Endangered Species by the Government of Japan, in order to protect and conserve the species and its habitat. The rail is also subject to protection under the Japan Environmental Governing Standards (JEGS). Because the existence of the Okinawa Rail in the JWTC is known, we conducted a survey to reveal the current distribution of the rail in the JWTC. Since a previous distribution survey for the Okinawa Rail was conducted in 2004, we compared the current survey results to the 2004 survey results to ascertain if any differences existed between them.

Applying a Class 3 Grid employed by the Japan Ministry of the Environment (MOE) to the JWTC, its jurisdictional area was divided into 109 cells. The survey was conducted at 91 of the 109 cells from the 25th through the 30th of November 2009 using a play-back method. In each cell, one to three survey points were selected and a recorded song was played at the respective points to ensure that the recorded song was able to reach every part of the cell. When a responding call was heard, we considered that an Okinawa Rail was inhabiting the cell. The direction from the survey point to the responding rail, the estimated distance between the survey point and the rail, and the number of rails were recorded.


In this survey, inhabitation of the Okinawa Rail was confirmed in 49 cells, accounting for 53.8% of the 91 cells surveyed. The 49 cells were concentrated in the central and northern parts of the JWTC. There were no cells, where the response from the rail was heard, in the southern part, except cell N28. In each cell where a rail responded, one to six individual rails were distinguished (2.6 rails/cell on average).

EXECUTIVE SUMMARY

We examined changes in the Okinawa Rail distribution areas by comparing the results of 71 survey cells surveyed both in 2004 and 2009. We confirmed new inhabitation in 21 cells that had no response from a rail in 2004, while we could not confirm inhabitation in six cells where Okinawa Rails were detected in 2004. This result implied expansion of the Okinawa Rail distribution areas. Response counts of Okinawa Rails increased in many cells in 2009 in comparison with 2004. The results indicated that the distribution area and number have expanded from 2004, especially in the northern part of this survey area.

In the JWTC, alien species may be the main factor influencing the distribution of the Okinawa Rail. In accordance with the requirements of the JEGS, MCB Camp Butler routinely performs trapping and removal of alien carnivorous species from the JWTC in coordination with MOE and the Okinawa Prefectural Government (OPG). Areas where mongooses and roof rats were captured mostly overlapped with areas which had no rail response in this survey. These results also suggested that the alien species have a significant impact on the rail.

5 U.S.C. 552 (b) (5)



This report consists of four chapters and three appendices. The first element of the goal of this survey, to reveal the current distribution of the Okinawa Rail in the JWTC, is presented in Chapter 3. The second element of the goal of this survey, to compare the current distribution to the previous distribution surveyed in 2004, is presented in Chapter 4. The final element of the goal of this survey, to evaluate the actions taken to manage and protect the rail in the future, is presented in Chapter 4. The data table collections of this survey are presented in Appendix I. The survey point map collections are presented in Appendix II. The photo collections of this survey are presented in Appendix III.

TABLE OF CONTENTS

1. INTRODUCTION.....	1
1.1 Purpose of This Survey.....	1
1.2 Home to Okinawa Rail	2
1.3 Characteristics of Okinawa Rail	4
1.4 Distribution of Okinawa Rail in Northern Okinawa Island	6
2. SURVEY METHODS.....	9
2.1 Survey Cells	9
2.2 Survey Cells and Points.....	11
2.3 Calling Response Survey	11
3. RESULTS	15
4. DISCUSSIONS AND COMMENTS.....	17
4.1 Changes in Okinawa Rail Distribution Area and Southernmost Line	17
4.2 Factors Influencing Distribution of Okinawa Rail	20
4.3 Conservation Aspects of Rail Species on Okinawa and Other Islands.....	24
4.4 Recommendations for Conserving Okinawa Rail in JWTC	27
5. REFERENCES.....	29
6. LIST OF PREPARERS	35

LIST OF FIGURES

Figure 1-1 Location of the Ryukyu Archipelago, Okinawa Island, and Jungle Warfare Training Center (JWTC).....	3
Figure 1-2 An adult Okinawa Rail in a tree.....	5
Figure 1-3 Distribution of Okinawa Rail in Jungle Warfare Training Center in 2004.....	7
Figure 2-1 Survey cells and points in Jungle Warfare Training Center (JWTC).....	10
Figure 2-2 Digital player.....	13
Figure 2-3 External speakers.....	13
Figure 3-1 Cells of Okinawa Rail Inhabitation confirmed	16
Figure 4-1 Comparing the distribution of Okinawa Rail in 2009 and 2004.....	18
Figure 4-2 Response Counts from Okinawa Rail in Each Survey Cell in 2004 and 2009	19
Figure 4-3 Mongoose Captured Areas (Ministry of the Environment, 2008) and Okinawa Rail Inhabitation confirmed Areas.....	22
Figure 4-4 Roof Rat Captured Areas (Ministry of the Environment, 2008) and Okinawa Rail Inhabitation confirmed Areas.....	23
Figure 4-5 Flowchart of Okinawa Rail Conservation.....	26

LIST OF TABLES

Table 2-1 Survey cells and date.....	12
Table 4-1 Cell Number Status of Okinawa Rail Inhabitation in 2004 and 2009.....	17

LIST OF APPENDICES

APPENDIX I	Data Table Collections
APPENDIX II	Survey Point Map Collections
APPENDIX III	Photo Collections

1. INTRODUCTION

1.1 Purpose of This Survey

Okinawa rail (*Rallus Okinawae*), a bird species endemic to northern Okinawa Island, has been thought to be threatened with extinction since 1981 when it was first discovered as a new species. In order to protect and preserve the species and its habitat, the Government of Japan (GOJ) designated it as a Natural Monument in 1982 and a National Endangered Species in 1983. The rail is also subject to protection under the Japan Environmental Governing Standards (JEGS) as a Host Nation Protected Species.

Because the Jungle Warfare Training Center (JWTC) is situated in northern Okinawa Island, Marine Corps Base Camp Smedley D. Butler (MCB Camp Butler) conducted a survey to ascertain the distribution of the species in the JWTC in 2004. When the survey data of 2004 was compared to data obtained by Ozaki *et al.* (2002), which was one of the surveys conducted by local researchers in northern Okinawa Island, data suggested that the area inhabited by the species had decreased in the JWTC (Marine Corps Base Camp Smedley D. Butler, 2006).

The objective of this survey is to reveal the current distribution of the Okinawa Rail in the JWTC and to compare the current distribution to the previous distribution surveyed in 2004. The comparison will help us to ascertain if the area inhabited by the species has been decreasing in the JWTC.

1.2 Home to Okinawa Rail

Okinawa Island is situated at the approximate center of the Ryukyu Archipelago, a bow shaped archipelago stretching for 1,200 kilometers (746 miles) from Kyushu Island of Japan to Taiwan (Okinawa Prefectural Government, 2002) (Figure 1-1). The warm Kuroshio Current gives Okinawa its subtropical ocean climate. The average annual temperature is 21-24°C (70-75°F) with annual precipitation of 1,600-3,000 mm (63-118 in.) (Okinawa Prefectural Government, 2002). The northern part of Okinawa Island is mountainous with acidic and reddish-yellow soil (Kunigami-maji), while the central and southern part is lowland, with a soil of generally natural to weakly alkaline limestone (Shimajiri-maji) or immature mudstone (Jagaru) (Okinawa Prefectural Government, 2002).

The northern part of the island has been kept less-developed, while the central and southern part of this island has been developed as agricultural lands and residential areas. The forest in the mountainous areas of the northern part of the island mainly consists of Itajii or *Shiia* (*Castanopsis sieboldii*) (Niino and Miyagi, 1988). The forest is home to many endemic species such as the Pryer's Woodpecker (*Sapheopipo noguchii*), Ryukyu Robin (*Erithacus komadori komadori*), Namie's Frog (*Rana namiyei*) and others including the Okinawa Rail (Okinawa Prefectural Government, 2002). However, in recent times, the natural environment in the forest has been altered by expansion of agricultural and farm lands, construction of roads, and continuing deforestation (Niino and Miyagi, 1988).

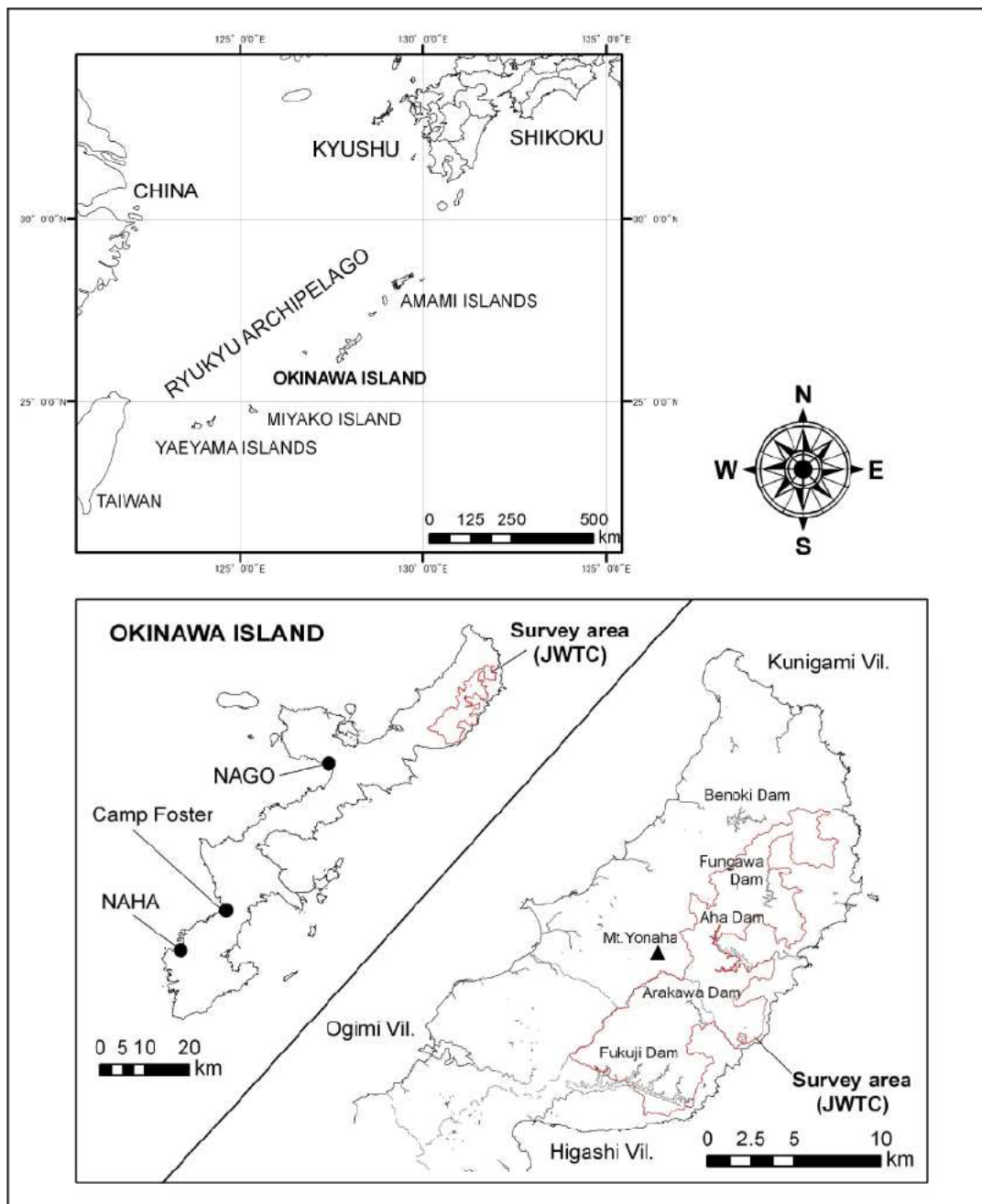


Figure 1-1 Location of the Ryukyu Archipelago, Okinawa Island, and Jungle Warfare Training Center (JWTC)

1.3 Characteristics of Okinawa Rail

The Okinawa Rail (*Gallirallus okinawae*), first discovered in 1981, is a nearly flightless bird endemic to northern Okinawa Island (Yamashina and Mano, 1981), and is classified in the Genus *Gallirallus* of the Family Rallidae in the Order Gruiformes (Taylor and Perlo, 1998). The rail has red stout legs and feet, short round wings, a short tail with bushy feathers, a bright blood-red iris, and black and white lateral wavy stripes from the breast to the belly (Ikehara, 1984; Kuroda, 1993; Taylor and Perlo, 1998) (Figure 1-2). The adult rail is 360 mm long with a wingspan of 500 mm (Kuroda, 1993). The downy young are covered with black down bristling over the whole body (Ikehara, 1984; Taylor and Perlo, 1998). The juvenile is relatively pale to the adult in color and has a somewhat mottled brownish bill and fleshy yellow-ocher legs (Yamashina and Mano, 1981).

The Okinawa Rail is either chiefly diurnal or partially crepuscular, and is an extremely vocal species that gives out a variety of calls in the early morning, late afternoon and early evening (Brazil, 1985; Ikenaga and Gima, 1993). Harato (1995) reported that the calls were heard best in August and November.

The rail spends most of its time on the ground in the forest where there are pools to bathe in and drink from with thick indeciduous tree cover, and roosts mostly in the Itajii tree (*Custanopsis sieboldii*) at night (Hanawa and Morishita, 1986; Harato and Ozaki, 1993; Kodaka, 2008). This species feeds mainly on animal matter, such as insects and terrestrial gastropods, but is also known to consume vegetable matter (Ikenaga, 1983; Ikenaga and Gima, 1993).

The breeding season of the rail is between March and June, when dish-shaped nests are made on the ground with dried and fallen leaves, and the clutch consists of two to five eggs (Chigira *et al.*, 1993; Gima, 1984; Harato, 1996; Ikehara, 1984). A breeding pair of the species alternately brood eggs until they hatch (Harato, 1996; Taylor and Perlo, 1998). During the time soon after hatching, the young birds are mostly hidden behind grasses, but after the elapse of a week or so, they move together with the parents (Ikehara, 1984).



Figure 1-2 An adult Okinawa Rail in a tree

1.4 Distribution of Okinawa Rail

Although the Okinawa Rail was known to inhabit Ogimi Village, Higashi Village and Kunigami Village prior to 1985, it became very hard to spot the species in these villages, except Kunigami Village, by the year 2005 (Ozaki, 2005). According to surveys conducted by Ozaki between 1996 and 1999 (Ozaki *et al.* 2002), the southernmost edge of the distribution of the species matched a line drawn between Janagusuku, Ogimi Village and Fukuji Dam in Higashi Village. The results of the 2000-2001 survey conducted by Ozaki indicated that the distribution area of the species had been narrowed and its southernmost edge had moved northward to the line drawn between Hiji, Kunigami Village and Oodomari, Higashi Village (Ozaki *et al.*, 2002). Ozaki (2005) estimated that the distribution of the Okinawa Rail had decreased approximately 40% in area between 1985 and 2003.

The first survey was conducted to ascertain the distribution of the Okinawa Rail in the JWTC by MCB Camp Butler in 2004, using a play-back method (Marine Corps Base Camp Smedley D. Butler, 2006). The existence of the species was identified only in 28.2% of the area surveyed and there were no responding rails in the southern part of the JWTC between Fukuji Dam Lake and Takae, Higashi Village (MCB Camp S. D. Butler 2006). The 2000-2001 survey conducted by Ozaki (Ozaki *et al.* 2002) covered more than half of the jurisdictional area of the JWTC as the study area, employed the play-back method, and was carried out during approximately the same season as when MCB Camp Butler conducted its survey in 2004. Thus, the results of the 2004 survey were compared to the results of the 2000-2001 survey, suggesting that the area inhabited by the rail had decreased throughout the JWTC and also that the southernmost edge of its distribution moved several kilometers toward the north (Marine Corps Base Camp Smedley D. Butler, 2006) (Figure 1-3).

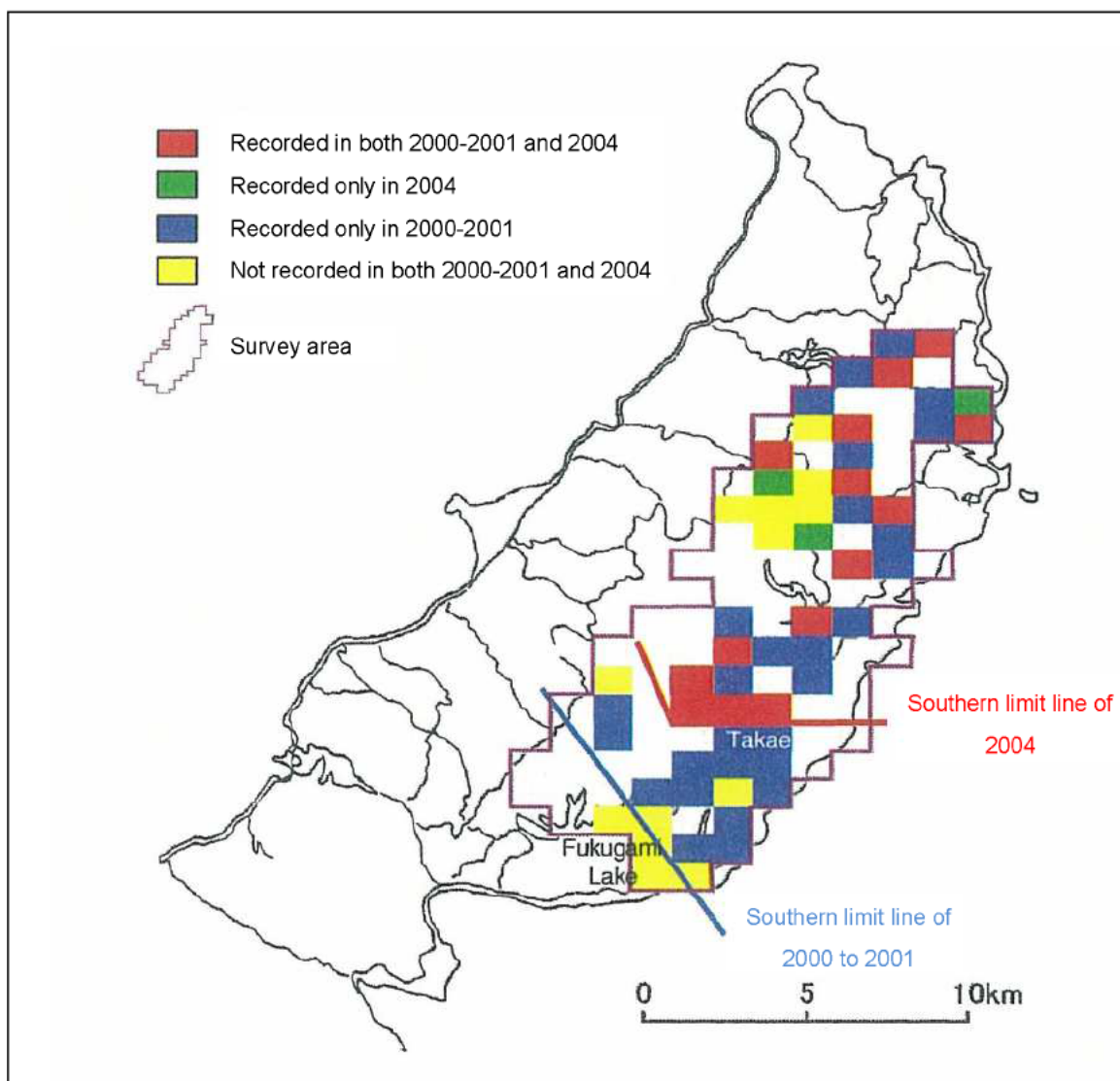


Figure 1-3 Distribution of Okinawa Rail in Jungle Warfare Training Center in 2004
(from Marine Corps Base Camp Smedley D. Butler 2006)

This page intentionally left blank

2. SURVEY METHODS

This survey employed a play-back method. The method refers to the utilization of a species tendency to respond to a song from a member of the same species. A recorded call of the Okinawa Rail was played to identify if any rails existed within the range where the played call can be reached.

2.1 Survey Area

The Jungle Warfare Training Center (JWTC), approximately 7,833 ha (19,356 acres) in area, is one of the US Marine Corps training areas and extends over Higashi Village and Kunigami Village in the northern part of Okinawa Island. The JWTC is about 87 km (52 miles) from Camp Foster, and transportation by road from the Camp to the JWTC takes about two hours (Marine Corps Base Camp Smedley D. Butler, 2009). The JWTC consists of the main compound, which provides administrative and operational support for the training of ground combat units of the III Marine Expeditionary Force, helo landing zones scattered over the training center, and other training facilities including bivouac sites and outdoor classrooms (Marine Corps Base Camp Smedley D. Butler, 2009). There are also four dams, Fukuji, Arakawa, Aha and Fungawa, with respective dam lakes in the JWTC. The dams and dam lakes are managed and maintained by the Okinawa General Bureau, GOJ. Other than the training facilities and dam facilities, there have been very few land modifications, and the majority of the JWTC still remains undeveloped and is covered with a plant community representing the natural forest of northern Okinawa Island, Okinawa-shikimi – Sudajii Community (Miyawaki and Okuda, 1989; Shinjo *et al.*, 1992).

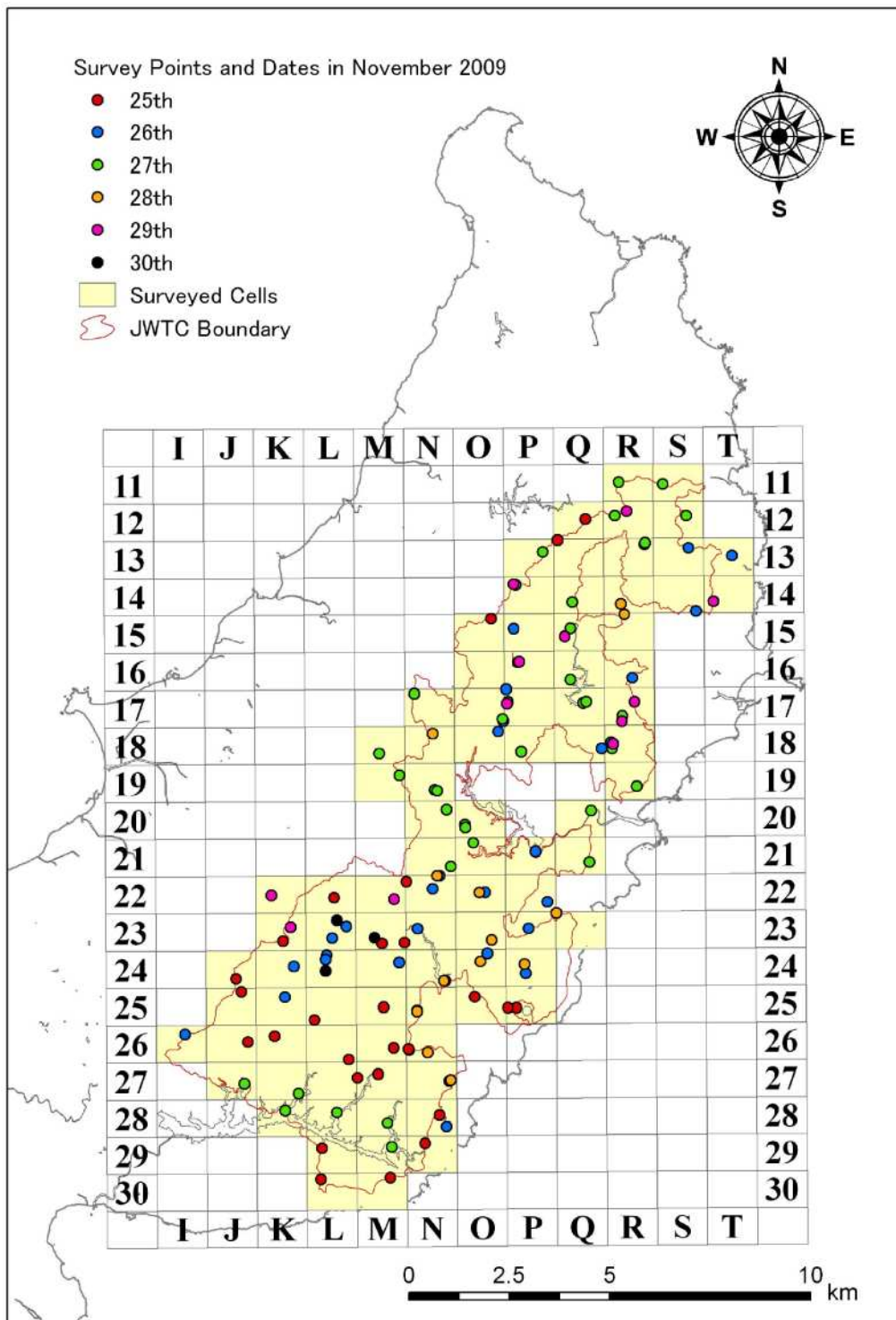


Figure 2-1 Survey cells and points in Jungle Warfare Training Center (JWTC)

2.2 Survey Cells and Points

Applying Class 3 Grid (the size of a mesh or a cell: 1.25 km from east to west × 0.925 km from south to north = 1.156 km²) for a natural conservation baseline survey employed by the Ministry of the Environment to the JWTC, its jurisdictional area was divided into 109 cells. Because 18 of the 109 cells were either difficult to gain access to or only partially included (less than 17%) within the JWTC, these cells were omitted from the survey area, reducing the number of survey cells to 91. These cells were used as a minimum survey unit, and the survey using a play-back method was conducted at each cell. In each survey cell, one to three points (survey points) were selected to ensure that the recorded call played was able to reach every part of the cell.

2.3 Calling Response Survey

The survey was conducted from the 25th through the 30th of November, 2009, in order to avoid the breeding season of this species (Table 2-1). The survey team consisted of one to five groups of two to three people each day. To gain access to each survey point in the survey cells, the existing roads, foot trails and the surface of Fukuji Dam Lake were utilized by car, on foot, and by boat, respectively. To conduct the survey, most of the survey points were visited after sunset because songs of the rail are often heard in the late afternoon and early evening (Brazil, 1985; Ikenaga and Gima, 1993). Mainly due to safety reasons, some survey points located in forests and on the surface of the lake were visited in the afternoon before sunset.

A play-back method used in this survey followed the method of Ozaki *et al.* (2002). A recorded call of the Okinawa Rail was played at approximately the same volume of the call sung by the species in the wild. The recorded call, which lasts for approximately 16 seconds, was played five times at approximately 80-second intervals at each survey point using a digital player with external speakers (Figures 2-2 and 2-3). When any responding call was heard, the direction from the survey point to the responding rail, the estimated distance between the survey point and the responding rail, and the number of responding rails were recorded and we considered that the Okinawa Rail inhabited the cell where the survey point was located.

At each survey point, coordinates of the location where the recorded call was played were taken with a portable GPS device and also marked on a topographic map (see Appendices I and II). Most of the survey was conducted in good weather with no rain and little or no wind because sounds made by strong winds or heavy rain can interrupt the surveyors from hearing the Okinawa Rail respond.

Table 2-1 Survey cells and date

Survey Date	Time	Place	Survey Cells
25th Nov.	Day time	road	-
		forest	K23, L22, M22, M25
	Night time	road	L25, L26, L27, L29, L30, M23, M26, M27, M30, N17, N24, N26, N27, N28, N29, O15, O25, P13, P14, P25, Q12, Q13, R11, R12
		forest	J24, J25, J26, K26
26th Nov.	Day time	road	-
		forest	O23, O24, P24
	Night time	road	K24, K25, L23, L24, M23, M24, N21, N22, N23, N25, N28, O16, O17, O18, O22, P15, P16, P17, P18, P21, P22, P23, R13, R16, R18, S11, S13, S14, T13, T14
		forest	I26, Q18
27th Nov.	Day time	road	N21
		forest	M18, M19, N19, N20, O20, O21, S12
		dam lake	J27, K27, K28, L28, M28, M29
	Night time	road	N17, O17, P13, P14, P16, P17, P18, Q14, Q15, Q16, Q17, Q20, Q21, R11, R12, R13, R17, R18, R19, S11
		forest	-
28th Nov.	Day time	road	-
		forest	N18, R14, R15
	Night time	road	N21, N24, N25, N26, N27, O22
		forest	Q23
29th Nov.	Day time	road	-
		forest	K22, M22,
	Night time	road	P14, P16, P17, Q15, R12, R17, R18, T14
		forest	K23
30th Nov.	Day time	road	L23, L24, M23



Figure 2-2 Digital player



Figure 2-3 External speakers

This page intentionally left blank

3. RESULTS

Responses of the Okinawa Rail living in the wild were detected in 49 cells, accounting for 53.8% of the 91 cells surveyed (Figure 3-1). The cells, in which a response from a rail was detected, were not evenly distributed in the JWTC, and were concentrated in its central and northern parts. There were no cells, where a response from a rail was heard, in the southern part of the JWTC except Cell N28.

At each cell where a response from a rail was detected, one to six individual rails were distinguished based on the direction and distance from the responding individuals (see Appendix I). There were 2.6 responding rails at each cell on average (128 responding rails/49 cells, Appendix I).

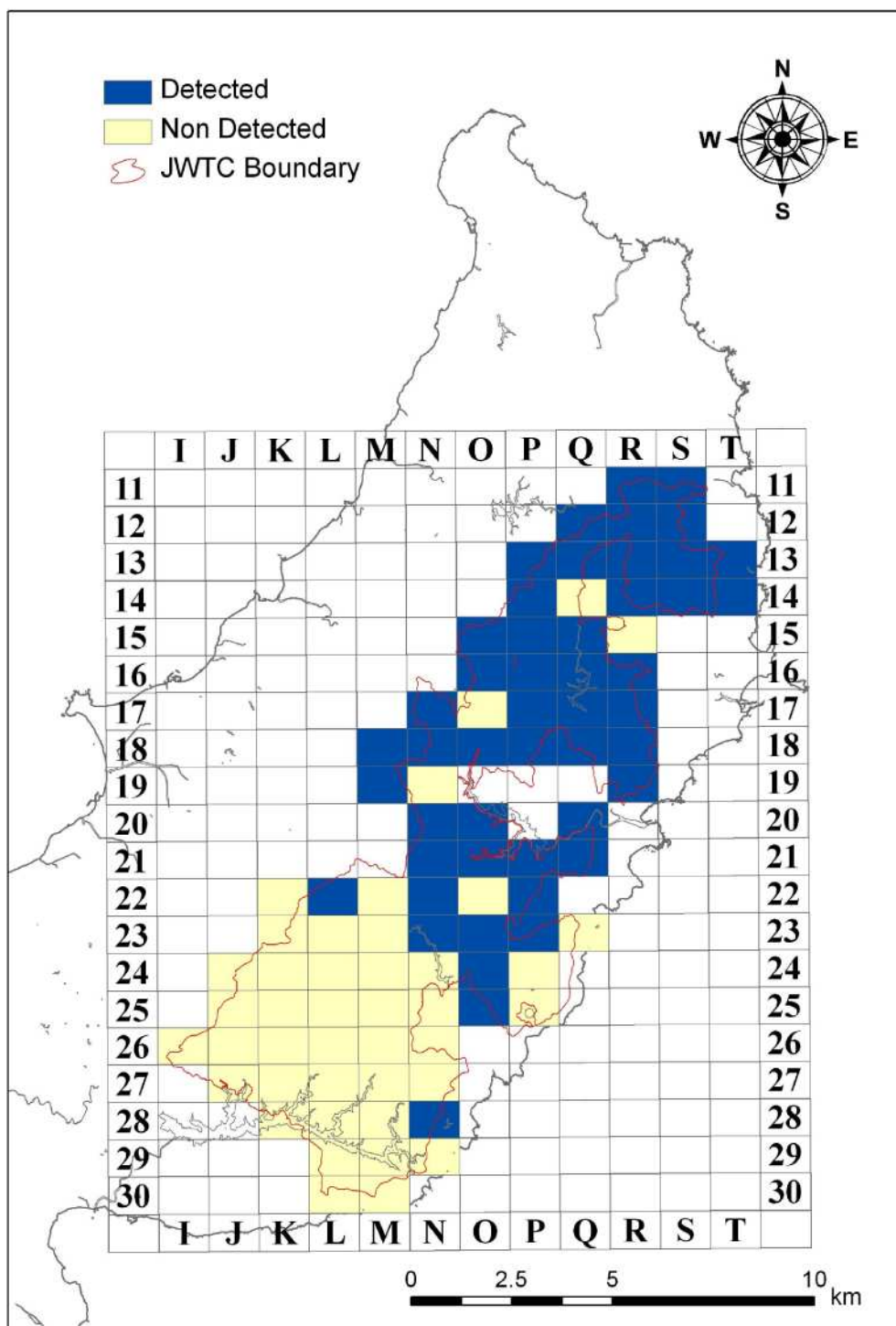


Figure 3-1 Cells of Okinawa Rail Inhabitation confirmed

4. DISCUSSIONS AND COMMENTS

4.1 Changes in Okinawa Rail Distribution Area and Southernmost Line

We examined the changes in Okinawa Rail distribution areas by comparing the results of 71 survey cells surveyed both in 2004 and 2009. We confirmed new inhabitation in 21 cells that had no response from the rail in 2004, while we could not confirm the inhabitation in six cells where Okinawa Rails were detected in 2004 (Table 4-1). This result implied the expansion of the Okinawa Rail distribution areas. We also showed response counts from the Okinawa Rail in each survey cell in Figure 4-2 and response counts in 2009 increased in many cells in comparison with 2004. For these reasons, the results indicated that the distribution area and number have expanded from 2004, especially in the northern part of this survey area (Figure 4-1).

Comparing the survey results in 2004 (Marine Corps Base Camp Smedley D. Butler, 2006) with 2000-2001 (Ozaki *et al.*, 2002), the southernmost limit of the distribution of the Okinawa Rail had moved to the north (Marine Corps Base Camp Smedley D. Butler, 2006) (Figure 1-3). However, we found that the southernmost distribution limit in 2009 had not changed very much since 2004 and inhabitation in Cell M23, M24, N24, and N25 was not confirmed in this survey (Figure 4-1).

It is concluded that the Okinawa Rail distribution area of 2009 did not decrease in the JWTC because 1) the number of cells with rail responses had increased since 2004, and 2) the distribution of cells responding in the southern part of the survey area has not changed very much since 2004. Therefore, it is expected that the decrease in the Okinawa Rail distribution had now stopped in the JWTC.

Table 4-1 Cell Number Status of Okinawa Rail Inhabitation in 2004 and 2009

		2009	
		Detected	Non Detected
2004	Detected	18	7
	Non Detected	21	25

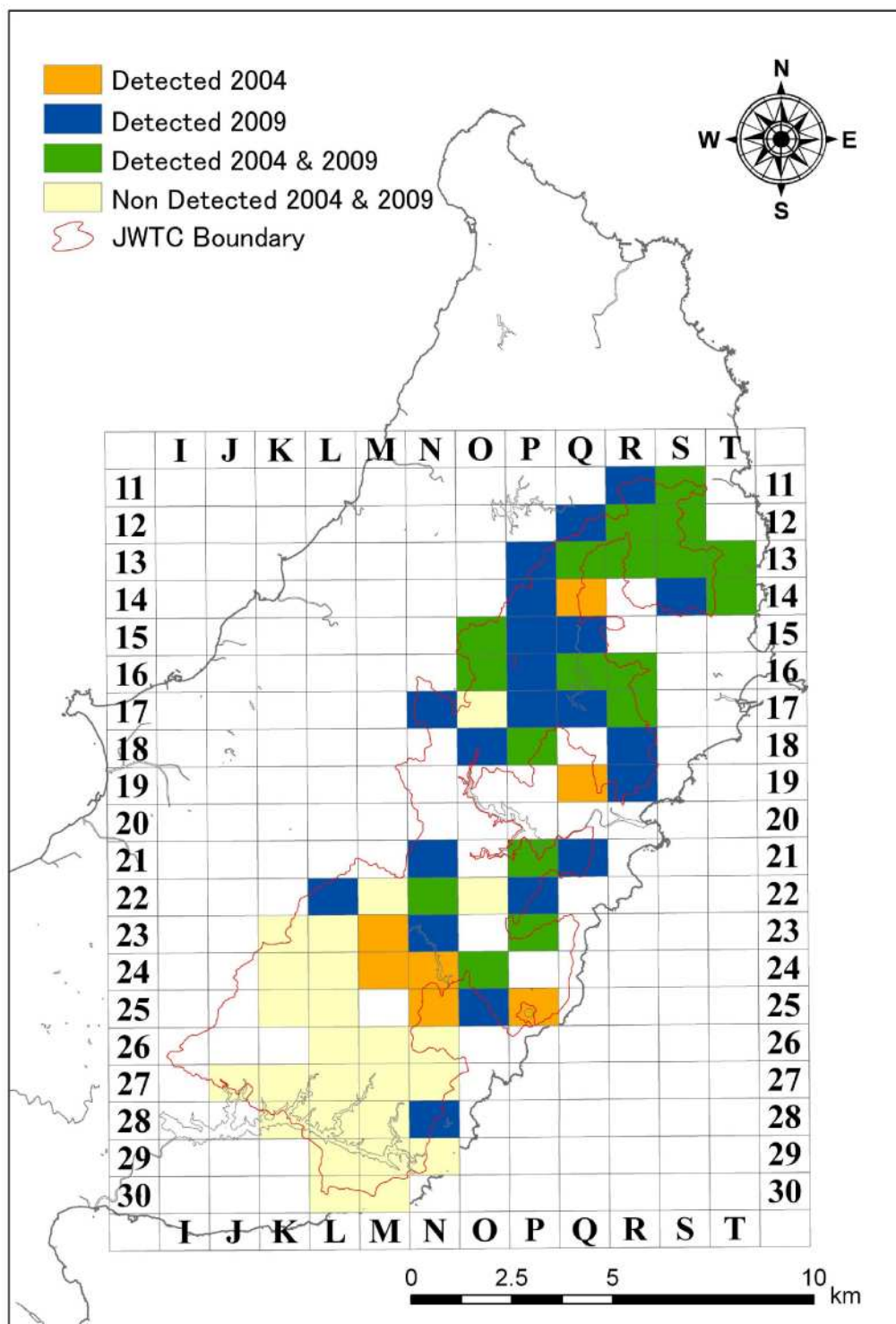


Figure 4-1 Comparing the Distribution of Okinawa Rail in 2009 and 2004.

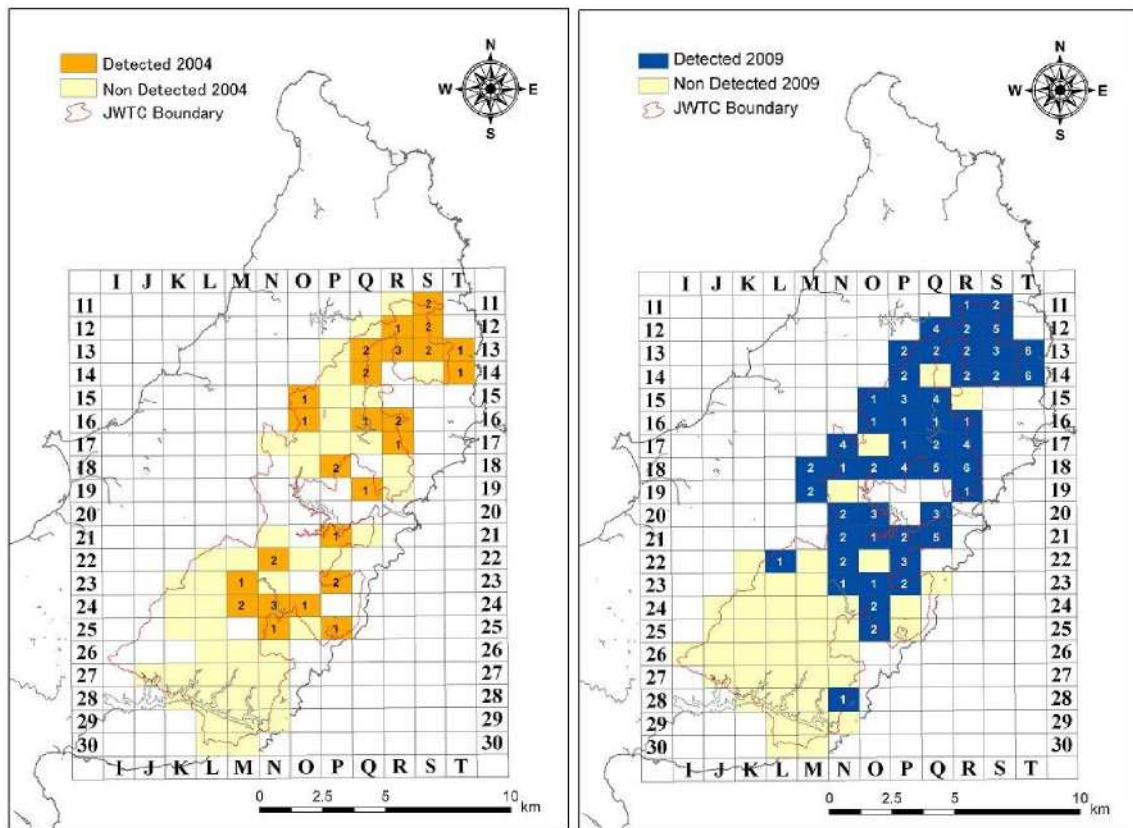


Figure 4-2 Response Counts from Okinawa Rail in Each Survey Cell in 2004 (left) and 2009 (right).

4.2 Factors Influencing Distribution of Okinawa Rail

It was reported that the habitat area and the number of Okinawa Rail had been decreasing in northern Okinawa Island (Ozaki, 2005; Ozaki, 2009) in recent years. 5 U.S.C. 552 (b) (5)

(Niino and Miyagi, 1998). There have been several reports of traffic accidents involving rails being struck (Kodaka, 2009; Ozaki, 2009), and this factor may not be ignored in the distribution of the Okinawa Rail. It is considered that alien species, especially carnivorous mongooses and feral cats brought onto Okinawa Island (Izawa 1997; Izawa, 2005), have had a negative impact on the inhabitation of the Okinawa Rail (Higa, 1993; Ozaki, 2002; Ozaki, 2005; Ozaki, 2009). In the JWTC, there was no large scale deforesting over the past several years, and traffic volume and traffic speed is strictly controlled. (b) (5)

(b) (5)

The mongoose is a diurnal, insectivorous carnivore (Hays and Conant, 2003). It feeds on birds, lizards, insects and other vertebrate species on other islands (Vilella, 1998; Oliver and Baldwin, 1953), and the (b) (5)

In addition to the impact from the mongoose, the influence of feral cats or dogs cannot be ignored. (b) (5)

It should be noted that there are alien roof rats (*Rattus rattus*) in northern Okinawa Island. The roof rat is a fruit- and animal-eating species (Abe, 2008), and it has been reported that they have preyed on the eggs and juveniles of birds and reduced the population of bird species in New Zealand and French Polynesia (Bell, 1978; James and Clout, 1996).

In accordance with the requirements of the JEGS, MCB Camp Butler routinely performs trapping and removal of mongoose and other alien carnivorous species in coordination with the Japanese Authorities to rid them from the JWTC. The Ministry of the Environment of Japan (MOE) and Okinawa Prefectural Government (OPG) have also been conducting mongoose capture projects in the JWTC since 2006 (Ministry of the Environment, 2006; Okinawa Prefectural Government, 2006). Figure 4-3 indicates areas where Okinawa rail inhabitation was confirmed in this survey and mongooses were captured by MOE and OPG (Ministry of the Environment, 2008). This figure illustrates that the areas where mongooses were captured were concentrated in the southern part, and these areas mostly overlapped with the area which had no response from the rail. It was reported that the frequency of the Okinawa Rail detected by sensor camera was lower in areas where detection of mongoose was higher (Kodaka, 2009). (b) (5)

We also show the distribution of the roof rat captured in mongoose eradication program in the northern part of Okinawa Island in 2008 (Ministry of the Environment, 2009) and the Okinawa Rail detected in this research (Figure 4-4). Many cells where roof rats were captured in 2008 overlapped with Okinawa Rail unidentified cells in this survey. (b) (5)

Native Jungle crow (*Corvus macrorhynchos*) had preyed on the eggs and juveniles of the Okinawa Rail (Ozaki, 2009) and other bird species (Kameda, 1994; Nakamura and Nakamura, 1995; Azuma *et al.*, 1996; Mochizuki and Ueda, 1996). The impact of the Jungle crow should be of concern because the population of this species tends to increase in northern Okinawa Island (Ozaki, 2005; Ozaki, 2009).

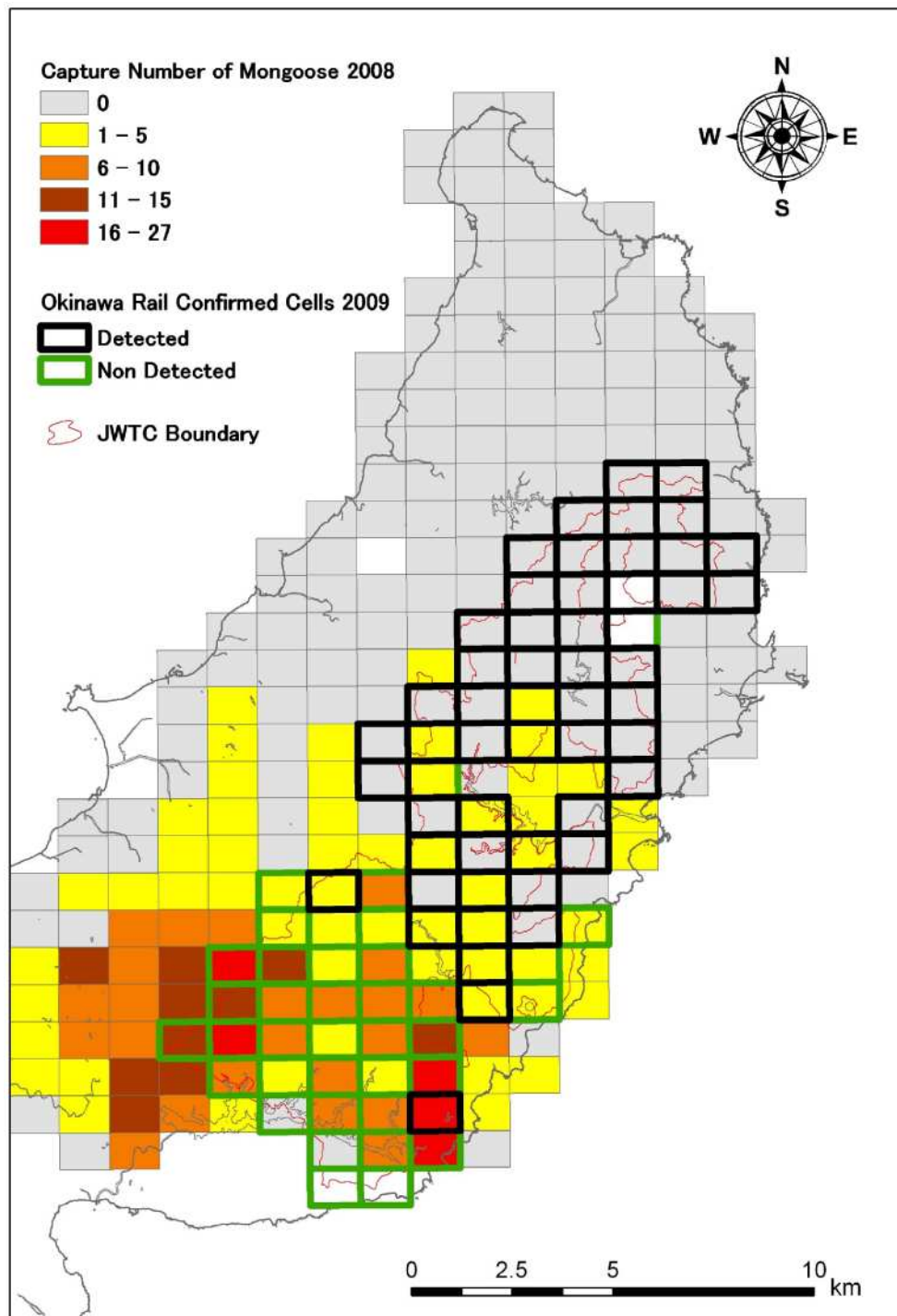


Figure 4-3 Mongoose Captured Areas (Ministry of the Environment, 2008) and Okinawa Rail Inhabitation confirmed Areas

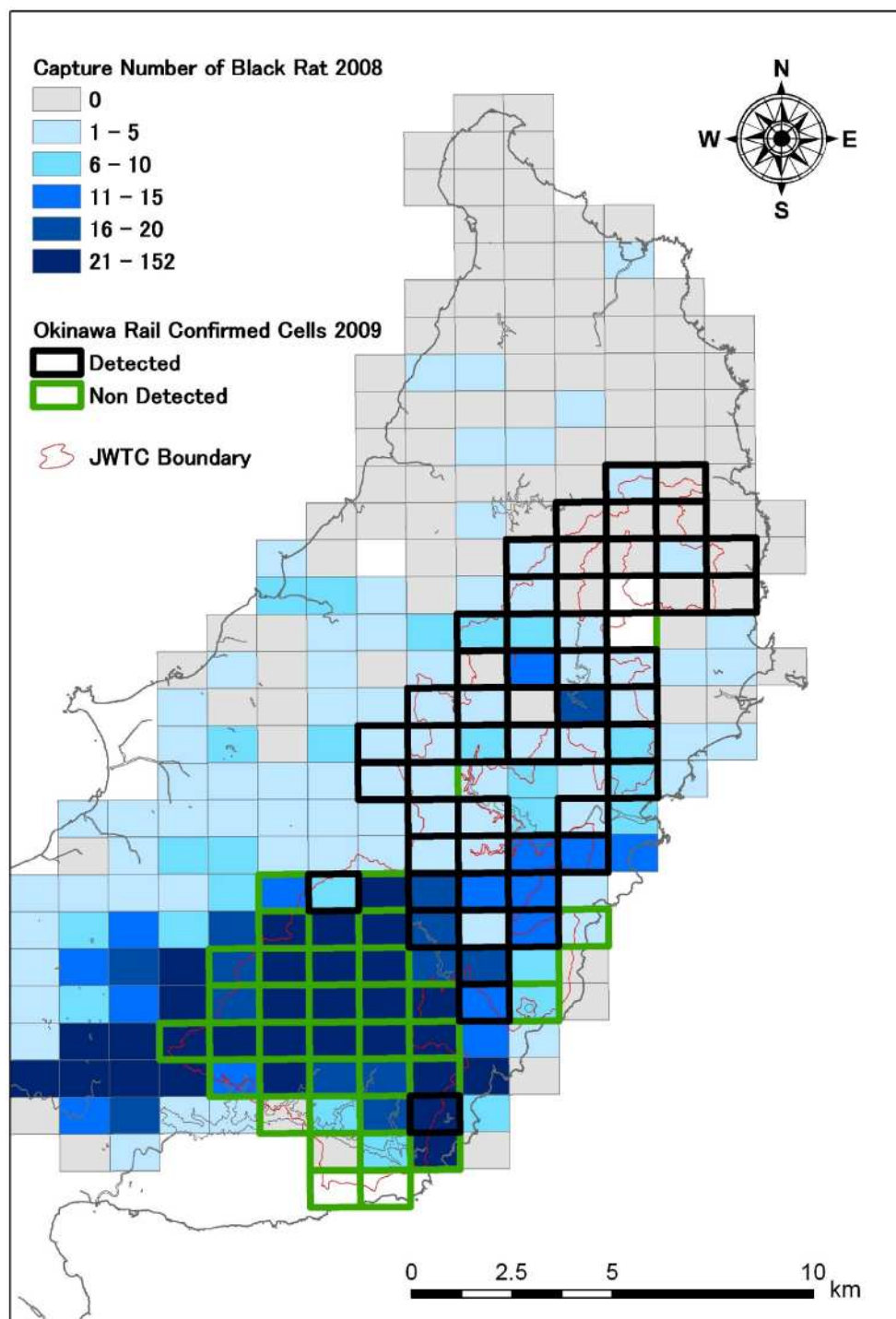


Figure 4-4 Roof Rat Captured Areas (Ministry of the Environment, 2008) and Okinawa Rail Inhabitation confirmed Areas

4.3 Conservation Aspects of the Rail Species

Due to the fact that the Okinawa rail has been threatened by alien carnivorous species, various conservation measures have been taken in recent years on Okinawa Island (Ministry of the Environment, 2009). A number of conservation measures have also been reported on unique flightless rails inhabiting islands overseas (Ozaki, 1995; Higuchi, 1996; Lorvelec *et al.*, 2004; Weninger & Momose, 2005; Ozaki, 2009). These reports indicate expectations for conserving the appropriate habitat and increasing the wildlife population of the Okinawa Rail. Three conservation aspects of the Okinawa rail, (1) eradication of alien carnivorous species, (2) installation and maintenance of a mongoose prevention fence, (3) conservation of habitat forests, and as one aspect to increase the rail species, (4) artificial breeding of rails, are described in detail in the following sections. The flowchart of Figure 4-5 illustrates these conservation aspects.

(1) Eradication of Alien Carnivorous Species

In order to protect rare species such as the Okinawa Rail from alien carnivorous species, MCB Camp Butler, OPG, and MOE have implemented eradication programs of alien carnivorous species in northern Okinawa Island. OPG started an eradication program on northern Okinawa Island in 2000 and at the JWTC in 2004 (Okinawa Prefectural Government, 2004). MOE started its eradication program for mongoose and feral cats on northern Okinawa Island in 2002 (Ministry of the Environment, 2003) and at the JWTC in 2006 (Ministry of the Environment, 2007). Furthermore, bylaws for preventing the generation of feral cats have been in effect in Kunigami, Ogimi, Higashi Village (Izawa 2005; Sawashi 2005).

Until 2004, the southernmost distribution limit of the Okinawa Rail had moved northward and the habitat area size was considered decreasing (Ozaki, 2005). Results from this survey imply that the habitat area of the Okinawa Rail in the JWTC has been increasing and the southernmost distribution limit had not changed very much in comparison with 2004 (Figure 4-1 and Table 4-1). We consider the eradication programs mentioned earlier as the main factor of the habitat area increase. Thus, it is very important for the MCB to continue to implement this eradication effort especially in the southern part of the JWTC

where the Okinawa rail has not returned.

(2) Installation and Maintenance of Mongoose Prevention Fence

In 2006, OPG completed the construction of the mongoose prevention fence from Shioya (Ogimi Village) to Fukuji Dam Lake (Higashi Village) (Okinawa Prefectural Government, 2007). In conjunction with the capture projects, it is considered that the population of the mongoose has been consistently decreasing in northern Okinawa Island since the completion of the Mongoose Prevention Fence (Okinawa Prefectural Government, 2009; Ministry of the Environment, 2009).

(3) Conservation of Habitat Forests for Okinawa Rail

For preventing the extinction of the Okinawa Rail, it is recommended that conservation of forests be implemented. Even if the population of the Okinawa Rail is enlarged, the Okinawa rail cannot survive without habitat forests. Especially because the Okinawa Rail spends most of its time on the ground in the forest with thick deciduous tree cover (Hanawa and Morishita, 1986), conservation of the forest will result in maintaining a good habitat environment.

(4) Artificial Breeding of Rails

MOE completed a breeding facility and has been conducting a development project with artificial breeding technology since 2009 (Ministry of the Environment, 2009; Ozaki, 2009). On an island overseas, the population of the Load Howe Rail (*Tricholimnas sylvestris*) had significantly decreased to 30 individuals due to the impact from imported pigs (*Sus scrofa*). The pigs, however, were completely eradicated and the artificial breeding of the rails has taken place successfully (Ozaki, 1995). In another island overseas, the Guam rail (*Rallus owstoni*) had been predated by the non-native Brown Tree Snake (*Boiga irregularis*), and decreased to 21 individuals (Stattersfield and Capper, 2000; Takeshita, 2001). With the implementation of artificial breeding, the population of the rail increased to over 200, but the threat of extinction has not been removed due to the existing impact from feral cats and other invasive animals (Weninger and Momose, 2005; Ozaki, 2009). Thus, a plan for

artificial breeding, the establishment of a breeding method, and also a plan for reintroducing the rail into the wild are needed on Okinawa Island.

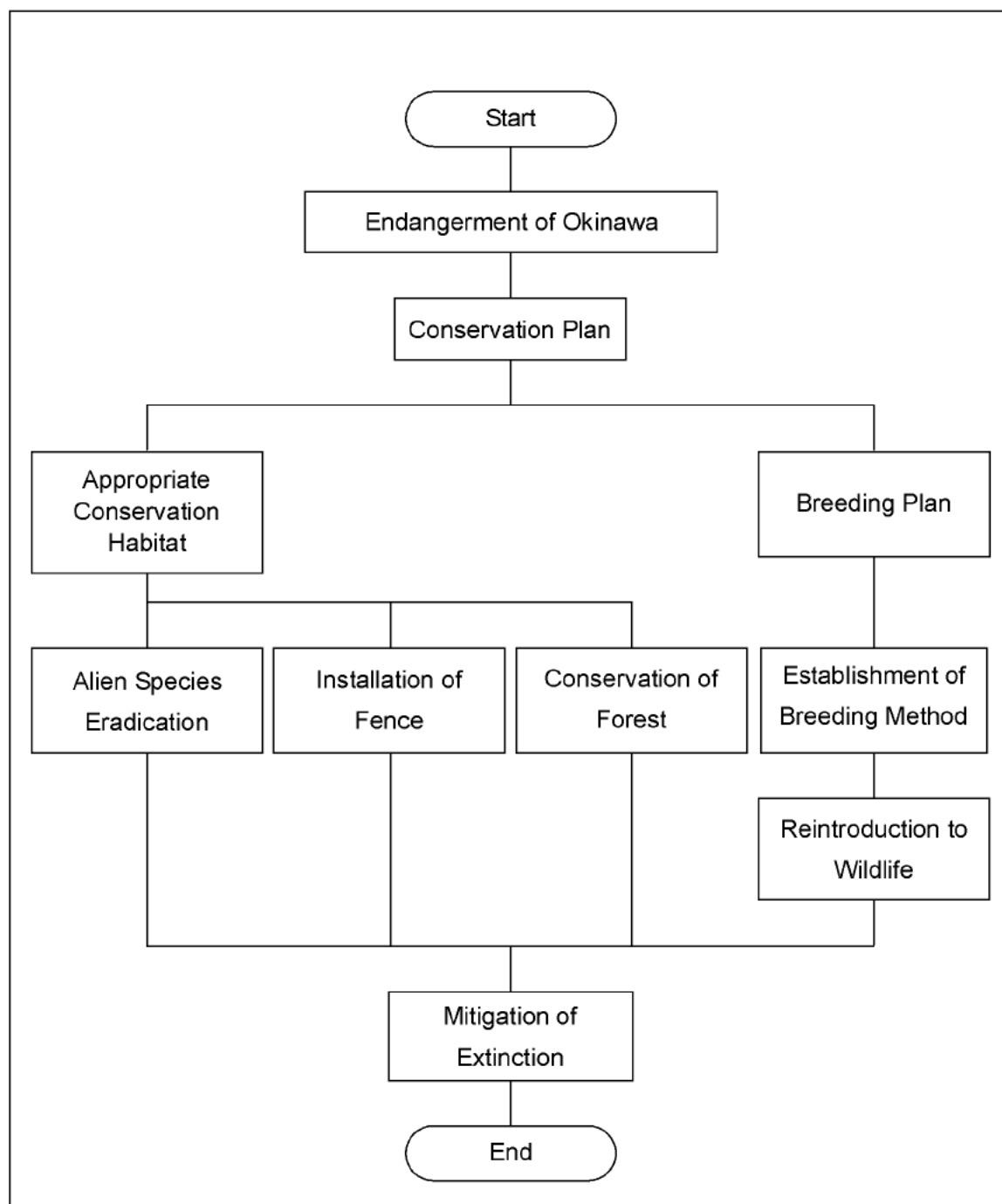


Figure 4-5 Flowchart of Okinawa Rail Conservation

This page intentionally left blank

5. REFERENCES

- Abe, H. (2008) Mammals in Japan. 2nd Ed. [Nihon No Honyurui Kaitei 2 Ban]. 206 pp, Tokai University Press, Kanagawa, Japan.
- Azuma Y., Kuwahara, K., and Kanai, Y. (1996) The breeding status and conservation plan of colony sites of the Little Tern (*Sterna albifrons*). Strix, 14, 143-157.
- Bell, B. D. (1978) The Big South Cape Islands rat irruption. Department of Lands and Survey Information Series, No.4, 33-37.
- Brazil, M. (1985) Notes on the Okinawa Rail *Rallus okinawae*: Observations at night and at dawn. Japanese Journal of Ornithology. 33, 125-127.
- Chigira, Y., Ikehara, S., and Takehara, K. (1993) Knowledge of the breeding of the Okinawa Rail (*Rallus okinawae*). [Yambaruikuina *Rallus okinawae* no Hanshoku ni kansuru Jakkan no Chiken]. Bulletin of Okinawa Prefectural Board of Education, 9, 1-11.
- Gima, C. (1984) An Okinawa Rail is born. [Yambaruikuina ga Umareta]. Anima, 12, 72-77.
- Hanawa, S. and Morishita, E. (1986) Distribution and population estimate of the Okinawa Rail. [Yambaruikuina no Bunpuiki to Kotaisuu no Suitei ni tsuite]. Research on special birds of the Japan Environmental Agency, 43-61.
- Harato, T. and Ozaki, K. (1993) Roosting behavior of the Okinawa Rail. Journal of Yamashina Institute for Ornithology, 25, 40-53.
- Harato, T. (1996) Ecology of Okinawa Rail. Symposium on the Okinawa Rail-Current research and conservation, and vision for the future-, [Yambaruikuina Symposium - Kenkyu • Hogo no Genjou to Shourai no Tenbou -]. Yamashina Institute for Ornithology, 15-20.
- Hays, W. S. T. and Conant, S. (2003) Male social activity in the small Indian mongoose *Herpestes javanicus*. Acta Theriologica. 48, 485-499.
- Higa, K. (1993) The northern part of Okinawa Island (Research on the distribution of special birds in the Village of Kunigami, Ogimi, and Higashi. [Okinawatou Hokubu Chiiki (Kunigamison • Ogimison • Higashison) ni okeru Tokushu Chourui no Seisoku Bunpu Chousa]. Research on the distribution of special birds VI, Okinawa Prefectural Government, 93-130.
- Higuchi, H. (1996) Mystery of the flightless bird - 15 Chapters for the ecology and evolution of birds-. [Tobenai Tori no Nazo -Tori no Seitai to Shinka wo Meguru 15 Shou-]. 280 pp. Heibonsha Limited Publishers, Tokyo.

- Ikehara, S. (1984) The Okinawa Rail is such a bird. [Yambaruikuina ha Konna Tori da]. *Anima*, 12, 78-79.
- Ikenaga, Y. (1983) Appearance Time and Behavior of the Okinawa Rail *Rallus okinawae* at a Water Site in the Late Afternoon. *Strix*. 2, 1-11.
- Ikenaga, Y. and Gima, C. (1993) Vocal Repertoire and Duetting in the Okinawa Rail *Rallus okinawae*. Research report of Yamashina Institute for Ornithology, 28-39.
- Izawa, M. (1997) Wild cat and mongoose. (Ikehara&Kato Ed.) Knowing the nature of Okinawa. [Yamaneko to Mangusu, (Ikehara&Kato Ed.) Okinawa no Shizen wo shiru]. 129-138 pp., Tsukijishokan Publishers, Tokyo.
- Izawa, M. (2005) Predation of Okinawa Rail by stray cat and mongoose. [Noneko, Mangusu ni yoru Yambaruikuina no Hoshoku]. *The Iden*, 59, 34-39.
- James, R. E. and Clout, M. N. (1996) Nesting success of New Zealand pigeons (*Hemiphaga novaeseelandiae*) in response to a rat (*Rattus rattus*) poisoning programme at Wenderholm Regional Park. *New Zealand Journal of Ecology*. 20, 45-51.
- Kameda, K. (1994) Identification of Nest Predators of the Rufous Turtle Dove *Streptopelia orientalis* by Video Tape Recording. *Japanese Journal of Ornithology* 43: 29-31.
- Kodaka, N., Kudaka, M., Takehara, K., and Sato, D. (2009) Ground use pattern by forest animals and vulnerability toward invasion by *Herpestes javanicus* into Yambaru, northern Okinawa Island, southern Japan. *Japanese Journal of Ornithology*, 58, 28-45.
- Kuroda, N. (1993) Morpho-anatomy of the Okinawa Rail *Rallus okinawae*. *Journal of Yamashina Institute Ornithology*. 25, 12-27.
- Lorvelec, O., Delloue, X., Pascal, M. and Mege, S. (2004) Impacts of invasive mammals on some native species on Fajou island established at the end of an attempted eradication. *Rev. Ecol. (in French)*, 59, 293-307.
- Marine Corps Base Camp Smedley D. Butler (2000) Integrated Natural Resources and Cultural Resources Management Plan. Marine Corps Base Camp Smedley D. Butler, Okinawa, Japan.
- Marine Corps Base Camp Smedley D. Butler (2002) Mongoose Monitoring Project in the Jungle Warfare Training Center. 52pp.
- Marine Corps Base Camp Smedley D. Butler (2006) Report on survey on Okinawa Rail at Jungle Warfare Training Center, Okinawa Japan. Marine Corps Base Camp Smedley D. Butler, Okinawa, Japan.

- Ministry of the Environment (2002) Report on the Conservation Project of wildlife in Yambaru Area.
- Ministry of the Environment (2003) Report on the Conservation Project of wildlife in Yambaru Area.
- Ministry of the Environment (2006) Red List of the bird.
<http://www.env.go.jp/press/press.php?serial=7849> (Retrieved March 31, 2010)
- Ministry of the Environment (2008) Reports on Mongoose Capture Project in Northern Part of Okinawa Island.
- Ministry of the Environment (2009) Press Release for Ministry of the Environment Okinawa Rail Breeding Facility, http://kyushu.env.go.jp/naha/pre_2009/0430a.html (Retrieved March 31, 2010)
- Miyawaki, A. and Okuda, S. (1989) Karte I, Actual vegetation map on Okinawa, South-west Japan. Vegetation of Japan. [Karte I Okinawa (Nansei Shotou) Genzon Shokuseizu. Nihon Shokuseishi]. Okinawa and Ogasawara, Shibundo Co. Ltd., Tokyo.
- Mochizuki, H. and Ueta, M. (1996) Decrease of Japanese Murrelets in Izu Islands, central Japan, *Strix*, 14, 173-176.
- Nakamura, T. and Nakamura, M. (1995) Birds' Life in Japan with Color Pictures -Birds of mountain, woodland and field-. 301 pp. Hoikusha Publishing Co. Ltd., Osaka.
- Niino Y. and Miyagi, K. (1988) The history of the forest of Yambaru. (Ikehara and Kato Ed.) The islands of Niraikanai, [Yambaru no Mori, Ima Mukashi, (Ikehara and Kato Ed.) Niraikanai no Shimazima], 127-148 pp. Tsukijishokan Publishers, Tokyo.
- Okinawa Prefectural Government (2002) Nature on Okinawa, Department of Cultural and Environment Affairs, Nature Conservation Division
- Okinawa Prefectural Government (2004) Report on mongoose eradication program. Okinawa Prefectural Government.
- Okinawa Prefectural Government (2005) Threatened Wildlife on Okinawa, 2nd Ed. (Animals) -Red Data Okinawa-. Japan Wildlife Research Center.
- Okinawa Prefectural Government (2006) Report on conservation project of ecosystem in northern part of Okinawa Island. Okinawa Prefectural Government.
- Okinawa Prefectural Government (2007) Report on conservation project of ecosystem in northern part of Okinawa Island. Okinawa Prefectural Government.
- Oliver, P. P. and Baldwin, P. H. (1953) Reproduction and age structure of a mongoose population in Hawaii. *Journal of Mammalogy*. 34, 436-447.

- Ozaki, K. (1995) Conservation of Gallirallus - Load Howe Rail-. [Kuina Rui no Hogo -Load Howe Kuina-]. Symposium on the Okinawa Rail -Current and future conservation-. 31-34.
- Ozaki, K. (2002) Threatened Wildlife of Japan -Red Data Book 2nd Ed.- Vol.2, Aves. 106-107pp. Japan Wildlife Research Center.
- Ozaki, K., Baba, T., Komeda, S., Kinjo, M., Toguchi, Y. and Harato, T. (2002) The Declining Distribution of the Okinawa Rail *Gallirallus okinawae*. Journal of the Yamashina Institute for Ornithology, 34, 136-144.
- Ozaki, K. (2005) The decrease in the distribution and population of the Okinawa Rail. [Yambarukuina no Bunpuiki to Kotaisuu no Genshou]. The Iden, 59, 29-33.
- Ozaki, K. (2009) Protection of Japanese Rare Birds. [Nihon no Kishou Chourui wo Mamoru]. Yamagishi, T. Ed.. 51-70 pp. Kyoto University Press, Kyoto.
- Sawashi, Y. (2005) The conservation of the forest of Yambaru area and Kunigami Village -Including Relationship with Local Residents -Current Situation of Environmental Conservation 40. [Yambaru, Kunigamison no Mori no Hozen -Chiiki Juumin tono Kakawari wo Hukumete -Kankyo Hozen no Genjou 40]. The Iden, 59, 84-90.
- Shinjo, K., Nijima, Y., Miyagi, C., Shimabukuro, K., Onaga, T., and Kanemoto, T. (1992). Comparative Study of Vegetation by age of stand in the East side of SEKIRYO Mountain and the northern Okinawa Island Study of the Special Bird Inhabitation Environment V Interim Report, [Okinawaken Hokubu Sekiryo Sanchi Higashigawa Chiiki ni okeru Rinrei ni yoru Shokusei no Hikaku Kenkyu. Tokushu Chouruito Seisoku Kankyo Chousa V Chuukan houkokusyo], Okinawa Prefectural Government. 1-122 pp.
- Stattersfield, A. J. and Capper, D. R. (ed.) (2000) Threatened Birds of the World. 852 pp. Lynx Editions.
- Sucheng C., Crosby, M. J., Islam, M. Z. and Tordoff, A. W. (2005) Important Bird Areas in Asia: Key Sites for Conservation (Birdlife Conservation Series). BirdLife International. 297 pp.
- Takeshita, N. (2001) Extinction or Expansion of the distribution? - A future of birds. Kawamichi, M., Iwatsuki K., Doumoto, A. Ed. -Import, Exotic, and Invasive Species-Threat to biological diversity-. [Zetsumetu ka Bunpu Kakudai ka, Toritachi no Asu. Inyu • Gairai • Shinnyusyu -Seibutsu Tayousei wo Obiyakasu Mono-]. 181-194 pp. Tsukijishokan Publishers, Tokyo.
- Taylor B. and Perlo, B. (1998) Rails -A Guide to the Rails, Crakes, Gallinules and Coots of

- the World-. 600pp. Pica Press, East Sussex.
- The Ryukyu Shimpo (2008) The feathers of the Okinawa Rail were detected in the scat of the mongoose. <http://ryukyushimpo.jp/news/storyid-137568-storytopic-5.html> (Retrieved May 15, 2010)
- Vilella, F. J. (1998) Biology of the mongoose (*Herpestes javanicus*) in a rain forest of Puerto Rico. Biotropica. 30, 120-125.
- Weninger, P. and Momose, H. (2005) Twenty years of conservation of the Guam rail. [Guamkuina Hogo no 20nen]. The Iden. 59, 45-49.
- Yamashina Y. and Mano, T. (1981) A New Species of Rail from Okinawa Island. Journal of Yamashina Institute for Ornithology, 13, 1-6.
- Yambaru Division of Wild Bird Society of Japan (1997) Report on the habitation situation of precious and imported animals and influence on precious animals by imported animals in the northern part of Okinawa Island. [Okinawatou Hokubu ni okeru Kichou Doubutsu to Inyuu dobutsu no Seisoku Jokyō oyobi Inyuu Doubutsu ni yoru Kichou Doubutsu heno Eikyou Houkokusyo]. 86pp.

This page intentionally left blank

Appendices

Appendix 1. Data Table Collections

Appendix 2. Surveyed Points Map Collections

Appendix 3. Photo Collections

1. Data Table Collections

Data table collections of calling response survey of Okinawa Rail (1/4)

Cell No.	Map No.	Cells Detected	Detect	Position	Night or Day	Date	Start time	Weather	Wind vane	Force of the Wind	1st time	2nd time	3rd time	4th time	5th time	Number of individuals	Presumption Pair	Latitude	Longitude
1	J26	5	-	x	Forest	Nighttime	26-Nov 22:10	Fine	East	Light breeze	x	x	x	x	x	0	0	26.6882	128.18028
2	J24	5	-	x	Forest	Nighttime	25-Nov 20:45	Fine	-	Calm	x	x	x	x	x	0	0	26.68093	128.19310
3	J25	5	-	x	Forest	Nighttime	25-Nov 21:25	Fine	-	Calm	x	x	x	x	x	0	0	26.67801	128.19440
4	J28	5	-	x	Forest	Nighttime	25-Nov 22:20	Fine	-	Calm	x	x	x	x	x	0	0	26.68881	128.19593
5	J27	5	-	x	Dam Lake	Daytime	27-Nov 16:14	Fine	East	Light breeze	x	x	x	x	x	0	0	26.65755	128.19500
6	K22	5	-	x	Forest	Daytime	29-Nov 11:24	Fine	-	Calm	x	x	x	x	x	0	0	26.69959	128.20190
7	K23	5	-	x	Road	Nighttime	25-Nov 19:10	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.69444	128.20482
8	K23	5	-	x	Forest	Daytime	29-Nov 13:34	Fine	-	Calm	x	x	x	x	x	0	0	26.69255	128.20667
9	K24	5	-	x	Road	Nighttime	26-Nov 19:41	Fine	East	Light breeze	x	x	x	x	x	0	0	26.68376	128.20750
10	K25	5	-	x	Road	Nighttime	26-Nov 20:00	Fine	East	Light breeze	x	x	x	x	x	0	0	26.67676	128.20514
11	K26	5	-	x	Forest	Nighttime	25-Nov 22:45	Fine	-	Calm	x	x	x	x	x	0	0	26.66810	128.20260
12	K27	5	-	x	Dam Lake	Daytime	27-Nov 15:37	Fine	East	Light breeze	x	x	x	x	x	0	0	26.65532	128.20852
13	K28	5	-	x	Dam Lake	Daytime	27-Nov 15:51	Fine	East	Light breeze	x	x	x	x	x	0	0	26.65148	128.20510
14	L22	8	L22	o	Forest	Daytime	25-Nov 13:45	Cloudy	-	Calm	x	x	315°400m1	x	x	1	1	26.69894	128.21764
15	L23	6	-	x	Road	Nighttime	26-Nov 19:15	Fine	East	Light breeze	x	x	x	x	x	0	0	26.69000	128.21708
16	L23	6	-	x	Road	Nighttime	26-Nov 20:45	Fine	East	Light breeze	x	x	x	x	x	0	0	26.69269	128.22065
17	L23	6	-	x	Road	Daytime	30-Nov 11:38	Cloudy	Northwest	Light breeze	x	x	x	x	x	0	0	26.69398	128.21838
18	L24	6	-	x	Road	Nighttime	26-Nov 19:27	Fine	East	Light breeze	x	x	x	x	x	0	0	26.68620	128.21574
19	L24	6	-	x	Road	Nighttime	26-Nov 20:27	Fine	East	Light breeze	x	x	x	x	x	0	0	26.68524	128.21547
20	L24	6	-	x	Road	Daytime	30-Nov 12:09	Cloudy	Northwest	Light breeze	x	x	x	x	x	0	0	26.68264	128.21542
21	L25	6	-	x	Road	Nighttime	25-Nov 20:25	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.67167	128.21259
22	L26	63	-	x	Road	Nighttime	25-Nov 19:52	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.68278	128.22112
23	L27	63	-	x	Road	Nighttime	25-Nov 20:56	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.65976	128.22324
24	L28	8	-	x	Dam Lake	Daytime	27-Nov 13:05	Fine	East	Light breeze	x	x	x	x	x	0	0	26.65093	128.21806
25	L29	8	-	x	Road	Nighttime	25-Nov 18:48	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.64292	128.21421
26	L30	8	-	x	Road	Nighttime	25-Nov 19:00	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.63597	128.21403
27	M18	3	M18	o	Forest	Daytime	27-Nov 10:55	Fine	East	Light breeze	x	230°50m2	x	x	x	2	1	26.73116	128.22907
28	M19	3	M19	o	Forest	Daytime	27-Nov 11:25	Fine	East	Light breeze	280°300m2	same	x	x	x	2	1	26.72826	128.23417
29	M22	36	N22	x	Forest	Daytime	25-Nov 16:10	Cloudy	-	Calm	x	x	x	x	45°50m1	1	1	26.70255	128.23570
30	M22	36	-	x	Forest	Daytime	29-Nov 15:00	Fine	-	Calm	x	x	x	x	x	0	0	26.69866	128.23264
31	M23	6	-	x	Road	Nighttime	25-Nov 21:59	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.68894	128.23510
32	M23	6	-	x	Road	Nighttime	25-Nov 21:47	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.68876	128.22954
33	M23	6	-	x	Road	Nighttime	26-Nov 18:58	Fine	East	Light breeze	x	x	x	x	x	0	0	26.69000	128.22773
34	M23	8	-	x	Road	Daytime	30-Nov 11:22	Cloudy	Northwest	Light breeze	x	x	x	x	x	0	0	26.69001	128.22769
35	M24	6	-	x	Road	Nighttime	26-Nov 21:00	Fine	East	Light breeze	x	x	x	x	x	0	0	26.68454	128.23380
36	M25	6	-	x	Forest	Daytime	25-Nov 14:50	Cloudy	-	Calm	x	x	x	x	x	0	0	26.67450	128.22988
37	M26	6	-	x	Road	Nighttime	25-Nov 21:12	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.66538	128.23237
38	M27	68	-	x	Road	Nighttime	25-Nov 19:32	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.65954	128.22843
39	M28	8	-	x	Road	Daytime	27-Nov 14:27	Fine	East	Light breeze	x	x	x	x	x	0	0	26.64852	128.23070
40	M29	8	-	x	Dam Lake	Daytime	27-Nov 14:42	Fine	East	Light breeze	x	x	x	x	x	0	0	26.64319	128.23167
41	M30	8	-	x	Road	Nighttime	25-Nov 19:15	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.63620	128.23135
42	N17	3	-	x	Road	Nighttime	25-Nov 18:43	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.74459	128.23792
43	N17	3	M17/N17	o	Road	Nighttime	27-Nov 19:48	Cloudy	East	Light breeze	x	x	x	240°100m2 240°300m2	x	4	2	26.74459	128.23792
44	N18	3	N18	o	Forest	Daytime	28-Nov 16:40	Cloudy	Northeast	Light breeze	170°200m1	x	x	x	x	1	1	26.73560	128.24250
45	N19	3	-	x	Forest	Daytime	27-Nov 12:13	Fine	East	Light breeze	x	x	x	x	x	0	0	26.72306	128.24827
46	N19	3	-	x	Forest	Daytime	27-Nov 12:42	Fine	East	Light breeze	x	230°100m1 same	x	x	x	0	0	26.72287	128.24348
47	N20	3	N20	o	Forest	Daytime	27-Nov 13:25	Fine	East	Light breeze	230°100m1	x	x	x	290°200m1	2	2	26.71862	128.24588
48	N21	36	-	x	Road	Nighttime	26-Nov 21:45	Fine	East	Light breeze	x	x	x	x	x	0	0	26.70380	128.24403
49	N21	36	N21	o	Forest	Daytime	27-Nov 15:33	Fine	East	Light breeze	30°100m2 same	x	30°100m2 same	x	x	2	1	26.70588	128.24885
50	N21	36	-	x	Road	Nighttime	28-Nov 19:42	Cloudy	North	Gentle breeze	x	x	x	x	x	0	0	26.70380	128.24343

Data table collections of calling response survey of Okinawa Rail (2/4)

No.	Cell No.	Map No.	Cells Detected	Detect	Position	Night or Day	Date	Start time	Weather	Wind vane	Force of the Wind	1st time	2nd time	3rd time	4th time	5th time	Number of individuals	Presumption Pair	Latitude	Longitude
51	N22	3.6	N22	o	Road	Nighttime	26-Nov	21:34	Fine	East	Light breeze	240'400m1.	x	x	x	x	2	2	26.70088	128.24227
52	N23	6	N23	o	Road	Nighttime	26-Nov	21:25	Fine	East	Light breeze	x	0'200m1	x	x	x	1	1	26.69204	128.23838
53	N24	6	-	x	Road	Nighttime	28-Nov	20:31	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.68037	128.24528
54	N24	6	-	x	Road	Nighttime	28-Nov	19:20	Cloudy	North	Gentle breeze	x	x	x	x	x	0	0	26.68037	128.24500
55	N25	6	-	x	Road	Nighttime	26-Nov	21:12	Fine	East	Light breeze	x	x	x	x	x	0	0	26.67370	128.23820
56	N25	6	-	x	Road	Nighttime	26-Nov	19:05	Cloudy	North	Gentle breeze	x	x	x	x	x	0	0	26.67343	128.23824
57	N26	6	-	x	Road	Nighttime	25-Nov	19:17	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.66477	128.23625
58	N26	6	-	x	Road	Nighttime	25-Nov	20:14	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.66505	128.23597
59	N26	6	-	x	Road	Nighttime	28-Nov	18:49	Cloudy	North	Gentle breeze	x	x	x	x	x	0	0	26.66436	128.24075
60	N27	6.8	-	x	Road	Nighttime	25-Nov	20:00	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.65796	128.24621
61	N27	6.8	-	x	Road	Nighttime	28-Nov	18:31	Cloudy	North	Gentle breeze	x	x	x	x	x	0	0	26.65815	128.24653
62	N28	8	-	x	Road	Nighttime	25-Nov	19:46	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.65032	128.24371
63	N28	8	N28	o	Road	Nighttime	26-Nov	20:44	Fine	East	Light breeze	350'400m1	x	x	x	350'400m1 same	1	1	26.64764	128.24538
64	N29	8	-	x	Road	Nighttime	25-Nov	19:30	Fine	Northeast	Light breeze	x	x	x	x	210'300m1	0	0	26.64399	128.24005
65	O15	1	O15	o	Road	Nighttime	25-Nov	19:05	Fine	Northeast	Light breeze	x	x	x	x	x	1	1	26.76116	128.25727
66	O16	1.4	O16	o	Road	Nighttime	26-Nov	18:46	Partly Cloudy	East	Light breeze	x	x	x	x	320'200m1	1	1	26.74551	128.26088
67	O17	3.4	P18	x	Road	Nighttime	26-Nov	19:06	Partly Cloudy	East	Light breeze	150'200m2	x	x	x	x	2	1	26.73833	128.26014
68	O17	3.4	-	x	Road	Nighttime	27-Nov	20:35	Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.73884	128.26000
69	O18	3	O18	o	Road	Nighttime	26-Nov	19:16	Partly Cloudy	East	Light breeze	280'200m2	x	x	x	x	2	1	26.73598	128.25894
70	O20	3	O20	o	Forest	Daytime	27-Nov	13:57	Fine	East	Light breeze	60'50m1	-	-	-	-	1	1	26.71519	128.25038
71	O20	3	O20	o	Forest	Daytime	27-Nov	14:00	Fine	East	Light breeze	40'70m1	x	40'70m2 same	x	110'50m1	3	2	26.71459	128.25046
72	O21	3	O20	o	Forest	Daytime	27-Nov	14:20	Fine	East	Light breeze	0'150m1	x	x	x	x	1	1	26.71107	128.25255
73	O22	3.7	-	x	Road	Nighttime	26-Nov	21:56	Fine	East	Light breeze	x	x	x	x	x	0	0	26.70010	128.25546
74	O22	3.7	-	x	Road	Nighttime	28-Nov	19:54	Cloudy	North	Gentle breeze	x	x	x	x	x	0	0	26.69995	128.25399
75	O23	7	-	x	Forest	Daytime	26-Nov	13:30	Fine	East	Light breeze	x	x	x	x	x	0	0	26.68940	128.25695
76	O23	7	O23	o	Forest	Daytime	26-Nov	14:30	Fine	Northeast	Light breeze	x	x	x	310'300m1	x	1	1	26.68940	128.25695
77	O24	7	-	x	Forest	Daytime	28-Nov	13:50	Fine	East	Light breeze	x	x	x	x	x	0	0	26.68639	128.25584
78	O24	7	O24	o	Forest	Daytime	28-Nov	15:05	Fine	Northeast	Light breeze	90'100m1	x	90'100m2 same	x	x	2	1	26.68463	128.25413
79	O25	7	O24,O25	o	Road	Nighttime	25-Nov	20:45	Fine	Northeast	Light breeze	325'300m1.	x	x	x	x	2	1	26.67862	128.25260
80	P13	1	P12,P13	o	Road	Nighttime	25-Nov	19:37	Fine	Northeast	Light breeze	305'300m1.	x	x	x	x	2	1	26.77612	128.27033
81	P13	1	-	x	Road	Nighttime	27-Nov	21:17	Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.77612	128.27033
82	P14	1	-	x	Road	Nighttime	25-Nov	19:19	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.76865	128.26343
83	P14	1	-	x	Road	Nighttime	27-Nov	19:20	Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.76865	128.26343
84	P14	1	P14	o	Road	Nighttime	29-Nov	18:45	Fine	North	Light breeze	320'100m2	x	x	x	x	2	1	26.76894	128.26292
85	P15	1	O15,P15	o	Road	Nighttime	26-Nov	18:23	Partly Cloudy	East	Light breeze	290'500m1	330'100m2	x	x	x	3	2	26.75899	128.26297
86	P16	1	-	x	Road	Nighttime	26-Nov	18:34	Partly Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.75153	128.26389
87	P16	1	-	x	Road	Nighttime	27-Nov	20:14	Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.75149	128.26389
88	P17	1	P16	o	Road	Nighttime	29-Nov	20:16	Fine	North	Light breeze	x	x	140'50m1	x	x	1	1	26.75158	128.26421
89	P17	1.4	-	x	Road	Nighttime	26-Nov	18:54	Partly Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.74269	128.26144
90	P17	1.4	-	x	Road	Nighttime	27-Nov	20:25	Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.74273	128.26144
91	P17	1.4	P17	o	Road	Nighttime	29-Nov	20:51	Fine	North	Light breeze	x	x	x	160'150m1	x	1	1	26.74232	128.26112
92	P18	4	-	x	Road	Nighttime	26-Nov	19:29	Partly Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.73144	128.26458
93	P18	4	P18	o	Road	Nighttime	27-Nov	20:46	Cloudy	East	Light breeze	130'200m2.	130'200m1 same	130'200m1 same	130'200m1 same	130'200m1 same	4	2	26.73144	128.26458

Data table collections of calling response survey of Okinawa Rail (3/4)

Cell No.	Map No.	Cells No. Detected	Detect	Position	Night or Day	Date	Start time	Weather	Wind vane	Force of the Wind	1st time	2nd time	3rd time	4th time	5th time	Number of individuals	Presumption Pair	Latitude	Longitude
94	P21	4	P21	o	Road	Nighttime	26-Nov 1944	Partly Cloudy	East	Light breeze	x	x	110'200m2	x	x	2	1	26.70921	128.26806
95	P22	4.7	P22	o	Road	Nighttime	26-Nov 1958	Partly Cloudy	East	Light breeze	250'500m1	x	x	50'300m2	x	3	2	26.69782	128.27093
96	P23	4.7	P23	o	Road	Nighttime	26-Nov 2207	Fine	East	Light breeze	30'150m2	x	x	x	x	2	1	26.69195	128.26821
97	P24	7	-	x	Forest	Daytime	26-Nov 1445	Fine	East	Light breeze	x	x	x	x	x	0	0	26.68190	128.26942
98	P24	7	-	x	Forest	Daytime	28-Nov 1535	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.68399	128.26510
99	P25	7	-	x	Forest	Nighttime	25-Nov 2101	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.67421	128.26310
100	P25	7	-	x	Road	Nighttime	25-Nov 2112	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.67417	128.26093
101	Q12	1	111Q12R1	o	Road	Nighttime	25-Nov 2006	Fine	Northeast	Light breeze	120'300m2	x	x	90'500m1	x	4	3	26.78338	128.28102
102	Q13	1	Q13	o	Road	Nighttime	25-Nov 1950	Fine	Northeast	Light breeze	180'300m2	x	x	x	x	2	1	26.77876	128.27398
103	Q14	1	-	x	Road	Nighttime	27-Nov 1856	Cloudy	East	Light breeze	70'400m1	x	x	x	x	0	0	26.76482	128.27759
104	Q15	1	Q15	o	Road	Nighttime	27-Nov 1838	Cloudy	East	Light breeze	335'200m1	x	x	x	x	4	4	26.75894	128.27709
105	Q15	1	Q15	o	Road	Nighttime	29-Nov 2023	Fine	North	Light breeze	310'100m2	x	x	x	x	2	1	26.75722	128.27565
106	Q16	1	Q16	o	Road	Nighttime	27-Nov 1927	Cloudy	East	Light breeze	x	x	x	x	180'50m1	1	1	26.74750	128.27704
107	Q17	1.4	-	x	Road	Nighttime	27-Nov 1834	Cloudy	East	Light breeze	x	x	x	x	same	0	0	26.74237	128.28014
108	Q17	1.4	Q17	o	Road	Nighttime	27-Nov 2146	Cloudy	East	Light breeze	220'200m2	x	x	x	x	2	1	26.74264	128.28088
109	Q18	4	Q18	o	Forest	Nighttime	26-Nov 1927	Fine	East	Light breeze	10'100m2	x	x	x	x	5	3	26.73208	128.28473
110	Q20	4	Q20	o	Road	Nighttime	27-Nov 1943	Cloudy	East	Light breeze	100'20m2	x	x	x	x	3	2	26.71825	128.28194
111	Q21	4	Q21	o	Road	Nighttime	27-Nov 1818	Cloudy	East	Light breeze	60'150m1	x	x	x	x	5	3	26.70667	128.28149
112	Q23	4.7	-	x	Forest	Nighttime	28-Nov 2010	Cloudy	North	Gentle breeze	270'200m2	310'400m2	x	x	300'200m1	0	0	26.69528	128.27315
113	R11	2	-	x	Road	Nighttime	25-Nov 2035	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.79167	128.28940
114	R11	2	R11	o	Road	Nighttime	27-Nov 1833	Cloudy	East	Light breeze	170'100m1	x	x	x	x	1	1	26.79167	128.28940
115	R12	2	-	x	Road	Nighttime	25-Nov 2019	Fine	Northeast	Light breeze	x	x	x	x	x	0	0	26.78412	128.28829
116	R12	2	-	x	Road	Nighttime	27-Nov 1848	Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.78412	128.28829
117	R12	2	R12	o	Road	Nighttime	29-Nov 1941	Fine	North	Light breeze	240'300m2	x	x	x	x	2	1	26.78510	128.29130
118	R13	2	-	x	Road	Nighttime	26-Nov 1925	Partly Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.77778	128.29574
119	R13	2	R12R13	o	Road	Nighttime	27-Nov 2108	Cloudy	East	Light breeze	350'500m1	180'300m1	x	x	x	2	2	26.77806	128.29584
120	R14	2	-	o	Forest	Daytime	28-Nov 1445	Cloudy	Northeast	Light breeze	x	x	x	x	x	0	0	26.76444	128.28977
121	R15	2	R14	x	Forest	Daytime	28-Nov 1524	Cloudy	Northeast	Light breeze	290'100m2	-	-	-	-	2	1	26.76204	128.29065
122	R16	2	R16	o	Road	Nighttime	26-Nov 2039	Partly Cloudy	East	Light breeze	x	290'30m1	x	x	x	1	1	26.74778	128.29245
123	R17	2.4	-	x	Road	Nighttime	27-Nov 1857	Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.73940	128.29000
124	R17	4	R17R18	o	Road	Nighttime	29-Nov 1900	Cloudy	North	Light breeze	125'200m1	-	-	-	-	1	1	26.73820	128.28986
125	R17	2.4	R17	o	Road	Nighttime	29-Nov 1930	Cloudy	North	Light breeze	x	220'30m2	240'100m1	215'300m1	x	4	3	26.74259	128.29306
126	R18	4	R18	o	Road	Nighttime	26-Nov 1900	Fine	East	Light breeze	120'200m2	70'150m2	-	-	-	6	4	26.73343	128.28704
127	R18	4	-	x	Road	Nighttime	27-Nov 1908	Cloudy	East	Light breeze	0'100m1	280'150m1	x	x	x	0	0	26.73195	128.28732
128	R18	4	R18	o	Road	Nighttime	29-Nov 1910	Cloudy	North	Light breeze	x	x	x	x	245'50m1	1	1	26.73310	128.28759
129	R19	4	R19	o	Road	Nighttime	27-Nov 1928	Cloudy	East	Light breeze	x	350'400m1	x	x	x	1	1	26.72357	128.29338
130	S11	2	-	x	Road	Nighttime	26-Nov 1843	Partly Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.79121	128.30046
131	S11	2	S11	o	Road	Nighttime	27-Nov 2017	Cloudy	East	Light breeze	x	x	x	x	200'150m1	2	2	26.79121	128.30042
132	S12	2	S12	o	Forest	Daytime	27-Nov 1515	Fine	East	Light breeze	x	x	x	335'150m1	115'50m1	5	4	26.78399	128.30616
133	S13	2	S12S13	o	Road	Nighttime	26-Nov 1906	Partly Cloudy	East	Light breeze	335'400m1	9'100m2	x	x	x	3	2	26.77690	128.30876

Data table collections of calling response survey of Okinawa Rail (4/4)

Cell No.	Map No.	Cells No. Detected	Detect	Position	Night or Day	Date	Start time	Weather	Wind vane	Force of the Wind	1st time	2nd time	3rd time	4th time	5th time	Number of individuals	Presumption Pair	Latitude	Longitude
134	S14	2	S14	o	Road	Nighttime	26-Nov 2021	Partly Cloudy	East	Light breeze	x	x	315°150m2	x	x	2	1	26.76264	128.30848
135	T13	2	T13	o	Road	Nighttime	26-Nov 19:51	Partly Cloudy	East	Light breeze	x	x	345°300m2 70°150m2	35°300m1 350°400m1	x	6	4	26.77510	128.31760
136	T14	2	-	x	Road	Nighttime	26-Nov 20:08	Partly Cloudy	East	Light breeze	x	x	x	x	x	0	0	26.76482	128.31306
137	T14	2	T14	o	Road	Nighttime	29-Nov 19:50	Cloudy	North	Light breeze	x	355°400m2	320°300m2	x	240°300m1 120°300m1	6	4	26.76477	128.31292

No. : Serial number.

Cell No. : Surveyed cell number.

Map No. : Number in the map shown in Appendix 3.

Cells Detected : Cells that confirmed reaction of Okinawa Rail.

Detect : Detected or non detected.

o : Detected
x : Non Detected

Position : Position in Survey point

Night or Day : Nighttime or Daytime

Date : Surveyed day.

Start time : Start time of survey.

Weather : Weather when surveying.

Wind vane : Wind vane when surveying.

Force of the Wind : Force of the wind when surveying.

1st - 5th time : Playback attempt time.

O° OmO: Degree of song direction. Approximate distance. Number of Confirmed individuals.
x : Non Detected

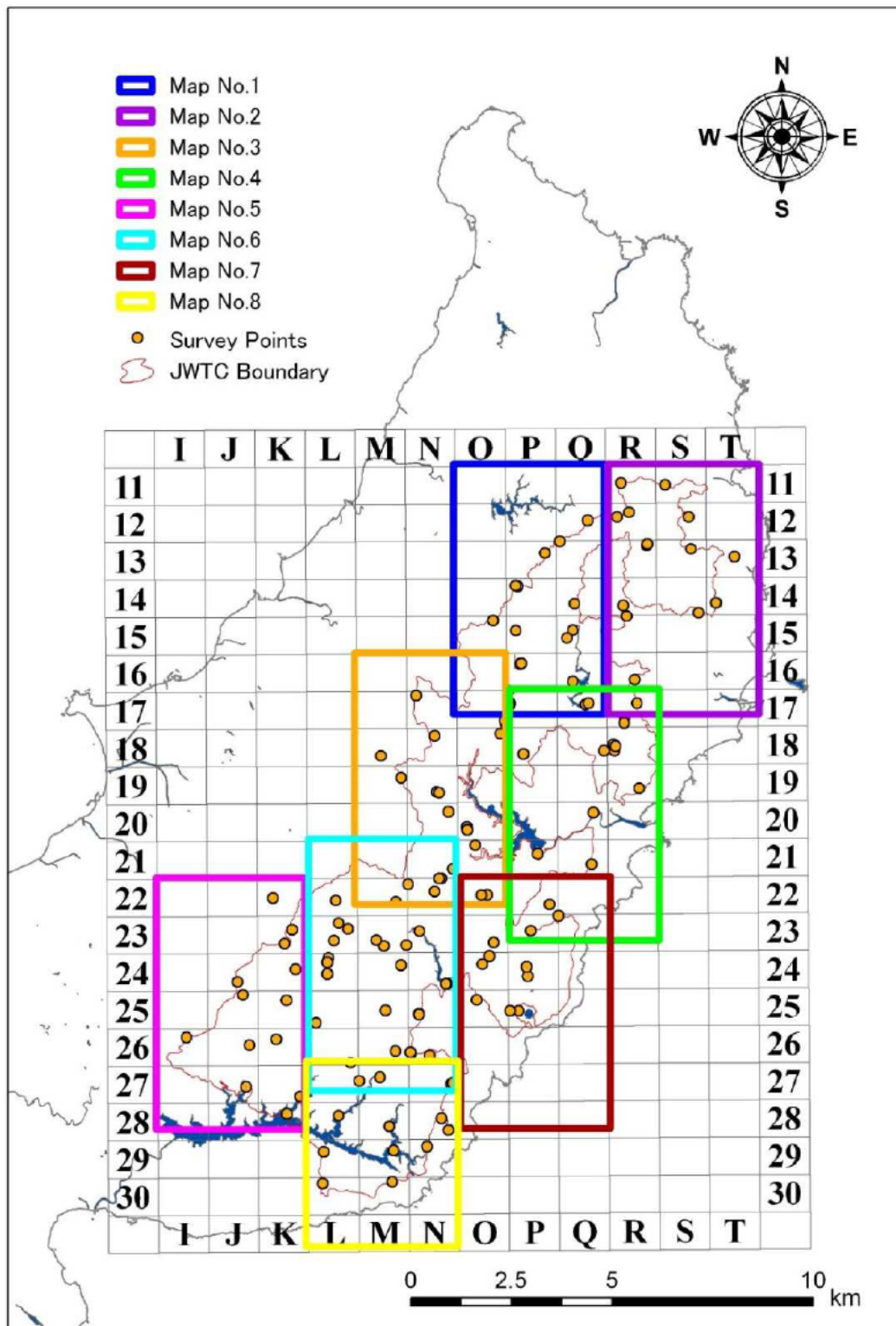
Number of individuals : Number of confirmed individuals in the cell.

Presumption Pair : Number of presumption pair in the cell. Presumption from Number of Confirmed individuals.

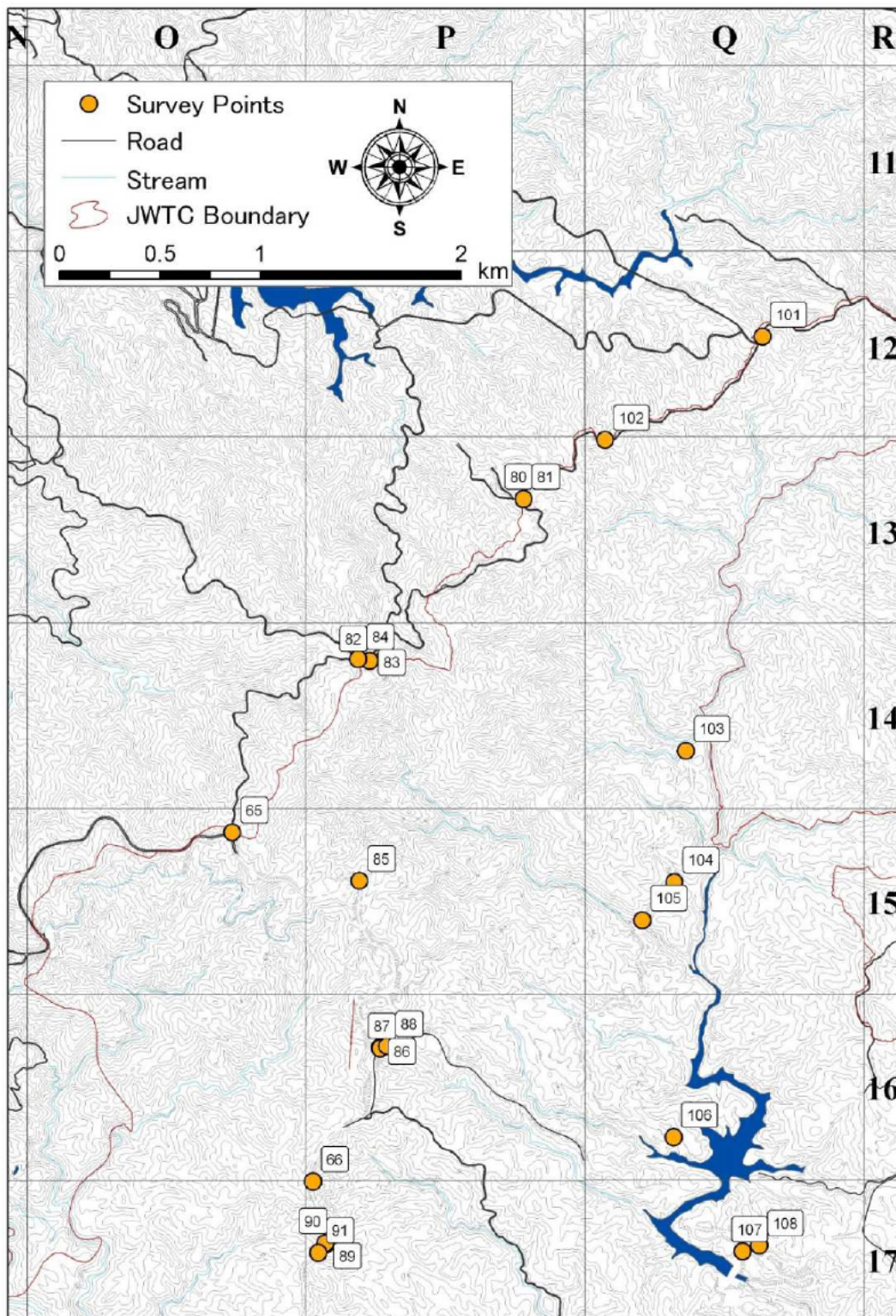
Latitude : Latitude of Surveyed point.

Longitude : Longitude in Surveyed spot.

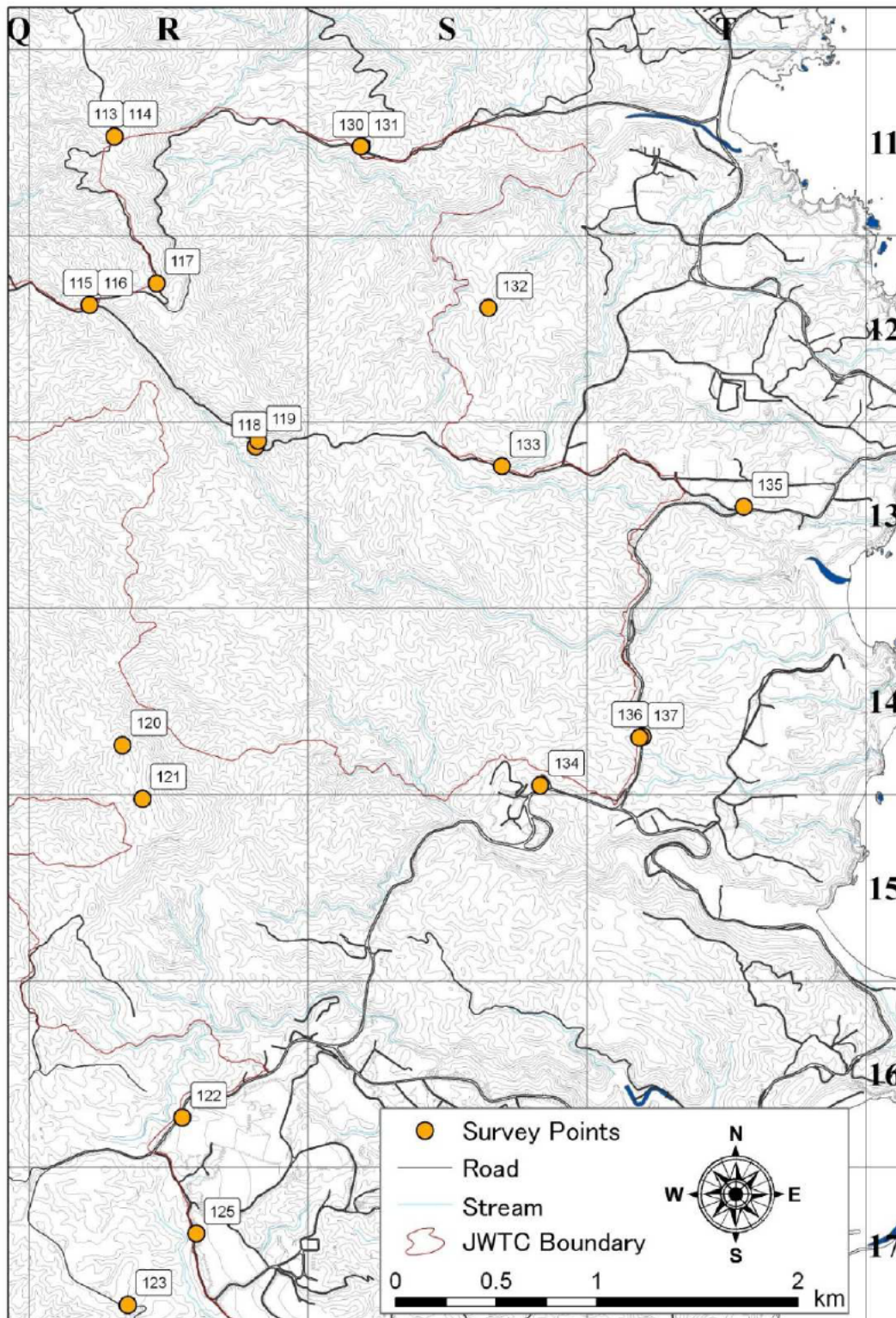
2. Surveyed Points Map Collections



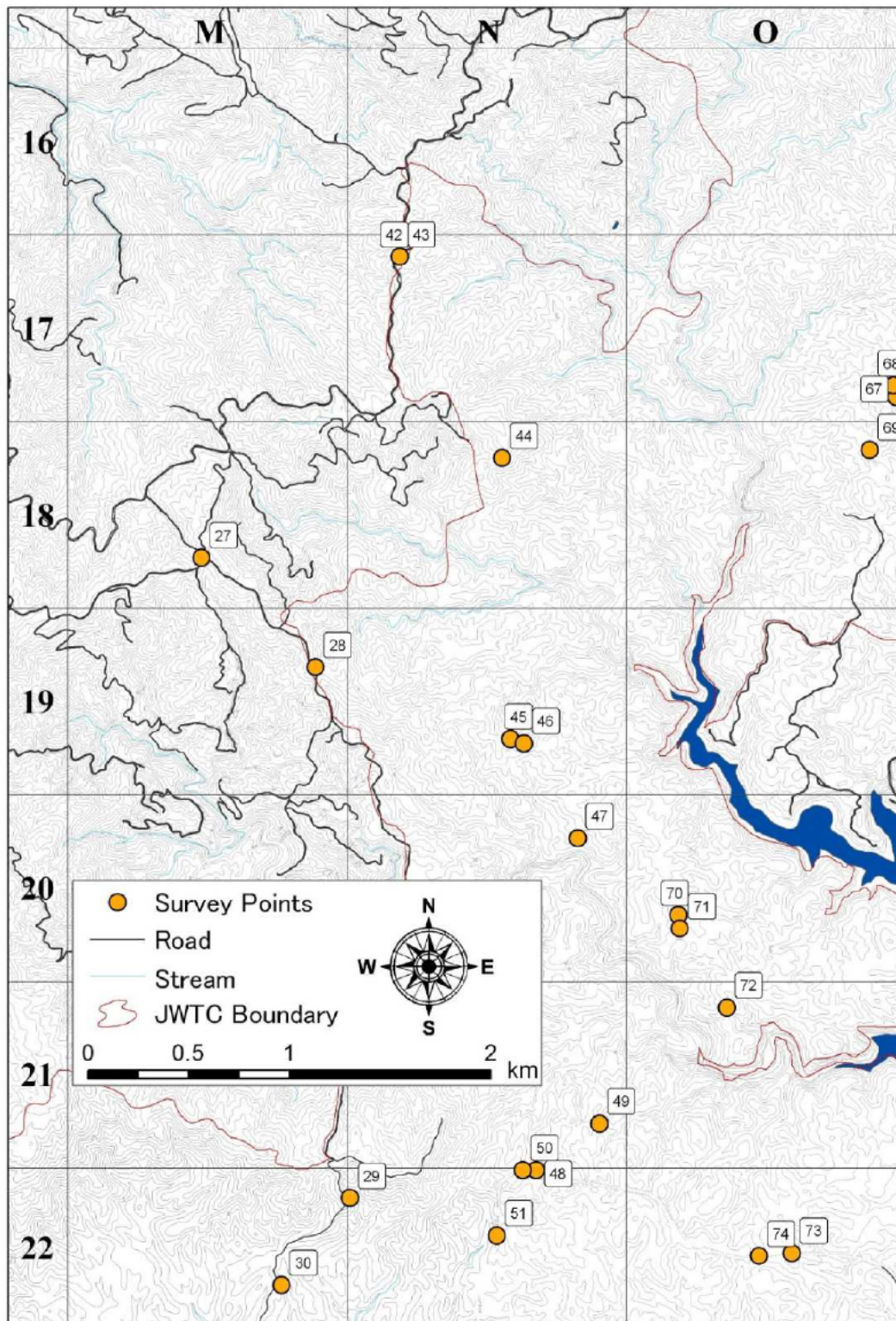
Appendix plate 1 Map Guidance



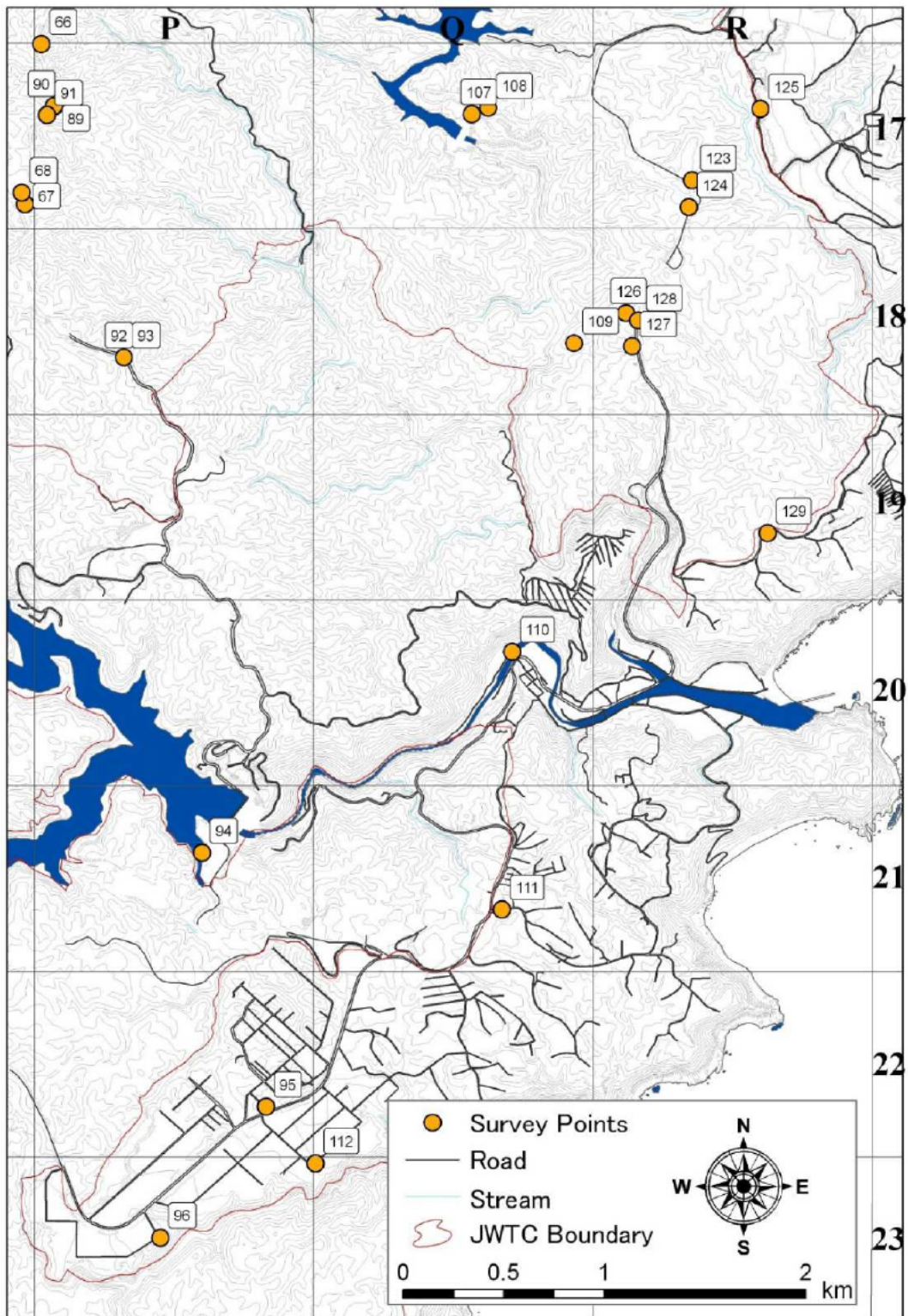
Appendix plate 2 Surveyed points of Map No. 1



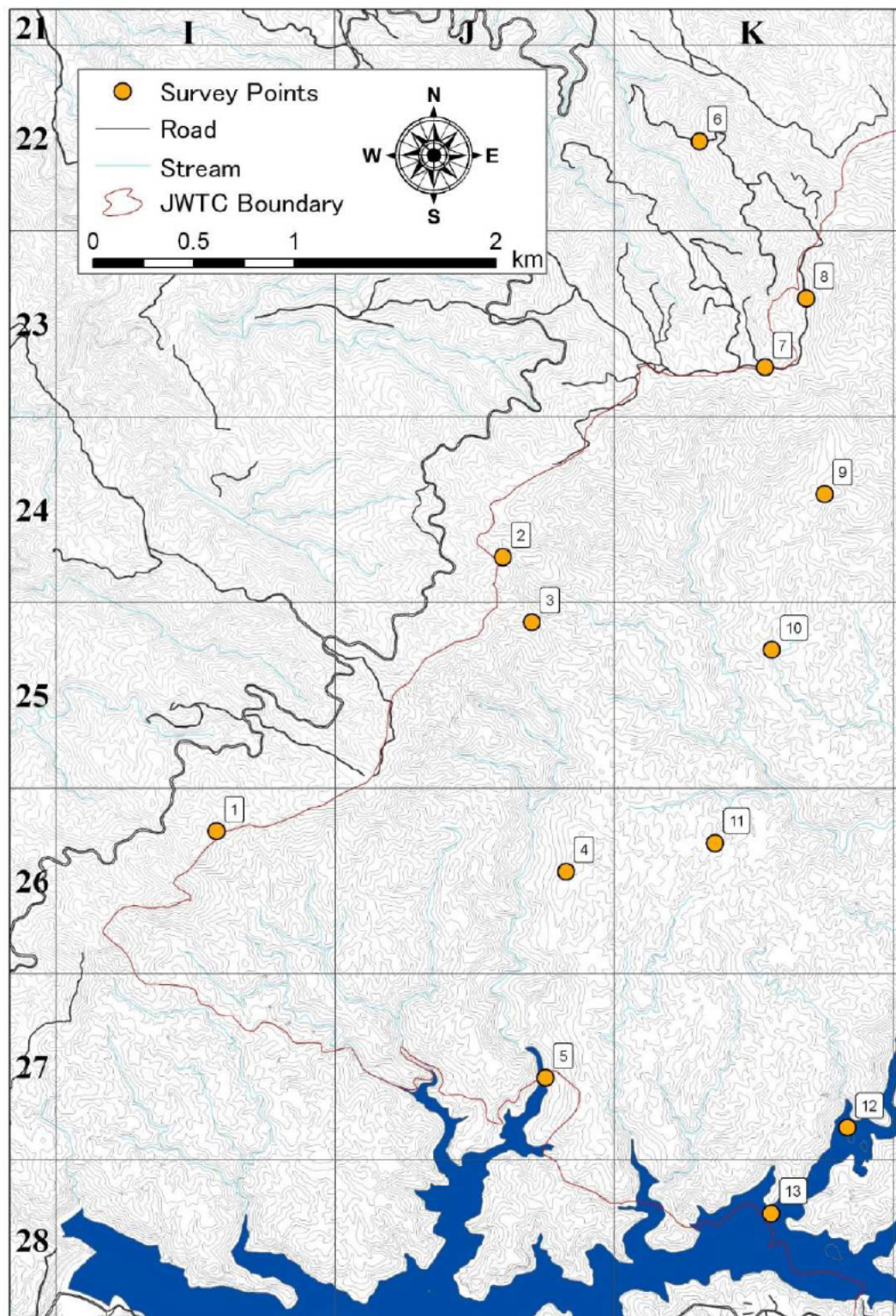
Appendix plate 3 Surveyed points of Map 2



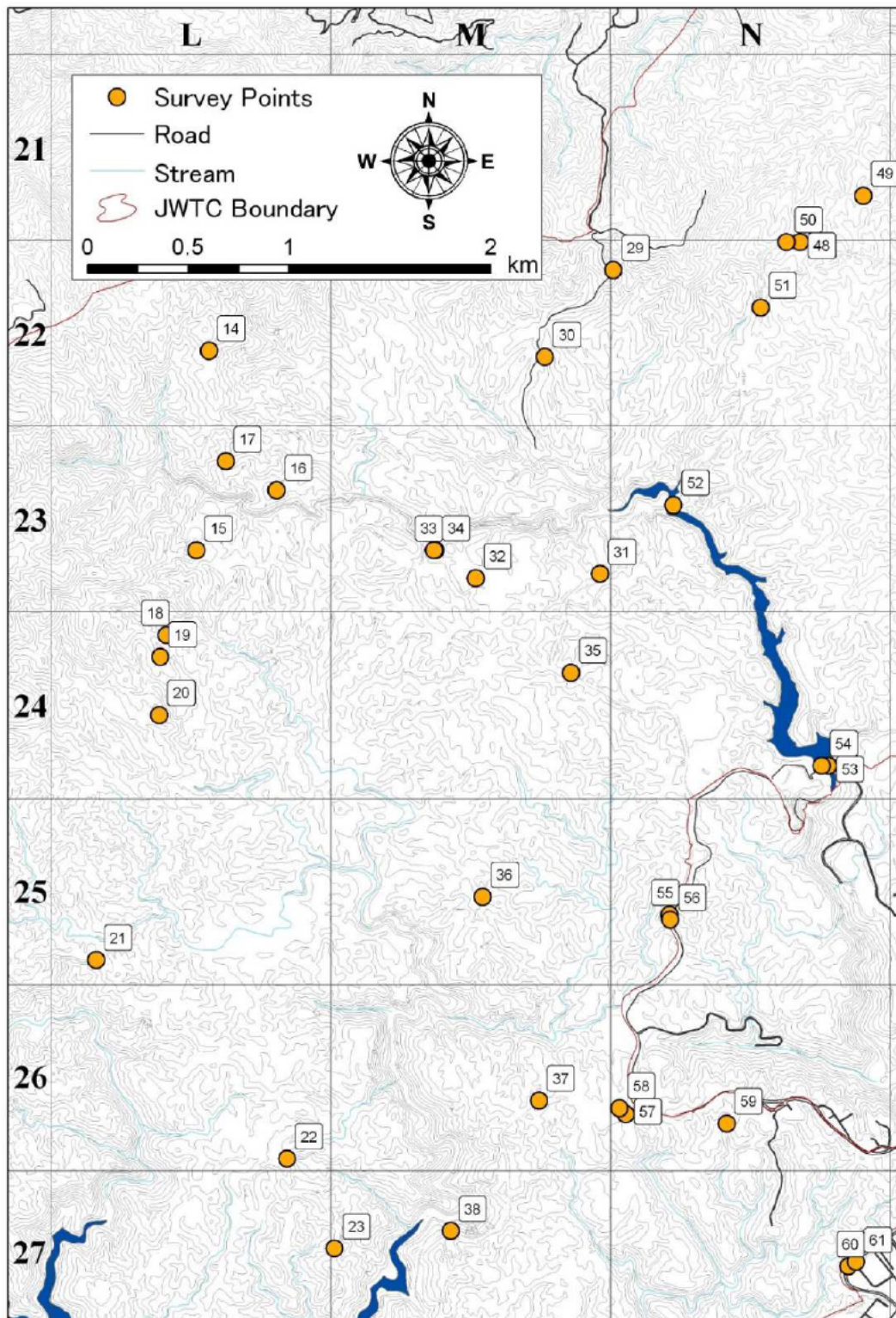
Appendix plate 4 Surveyed points of Map 3



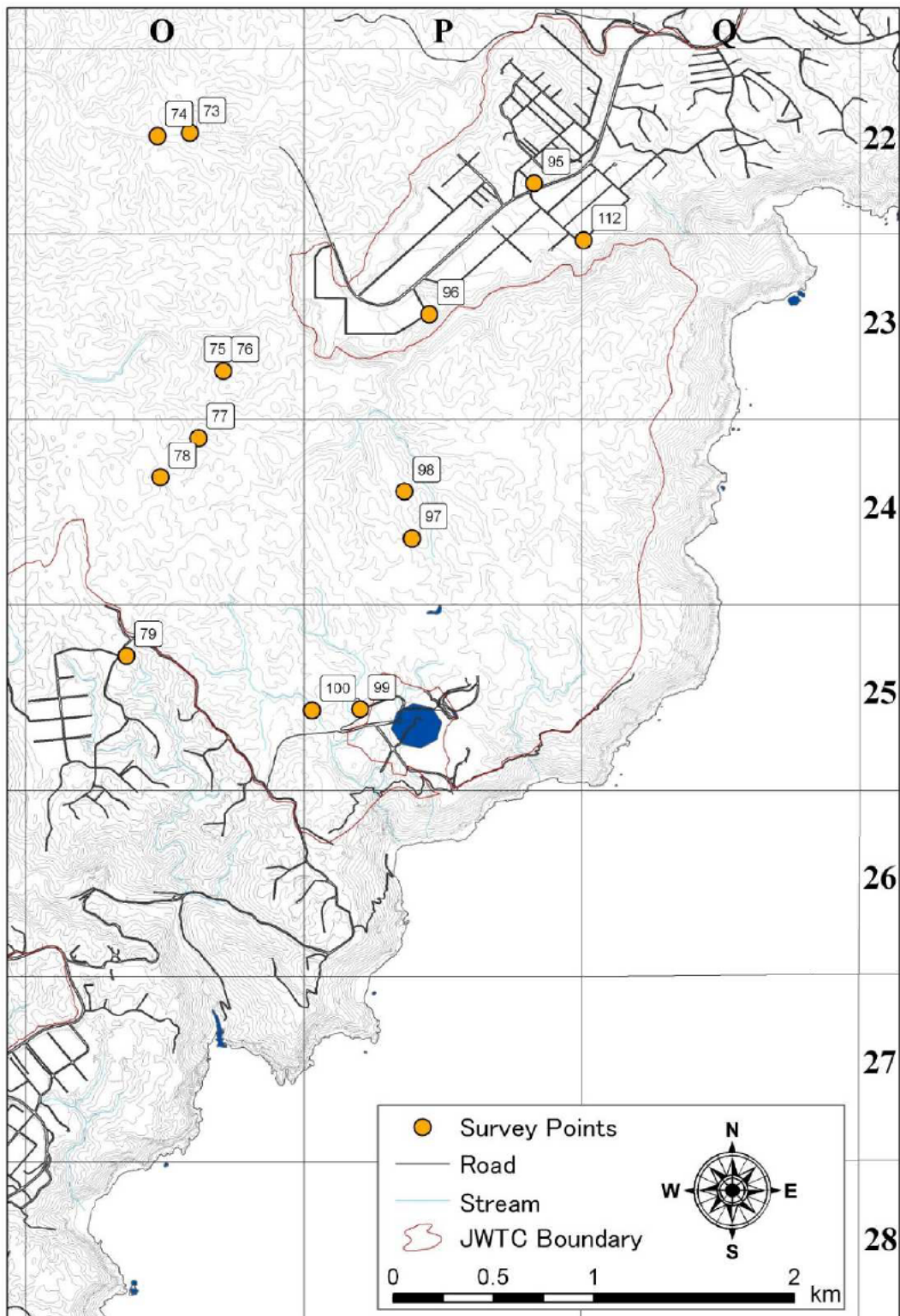
Appendix plate 5 Surveyed points of Map 4



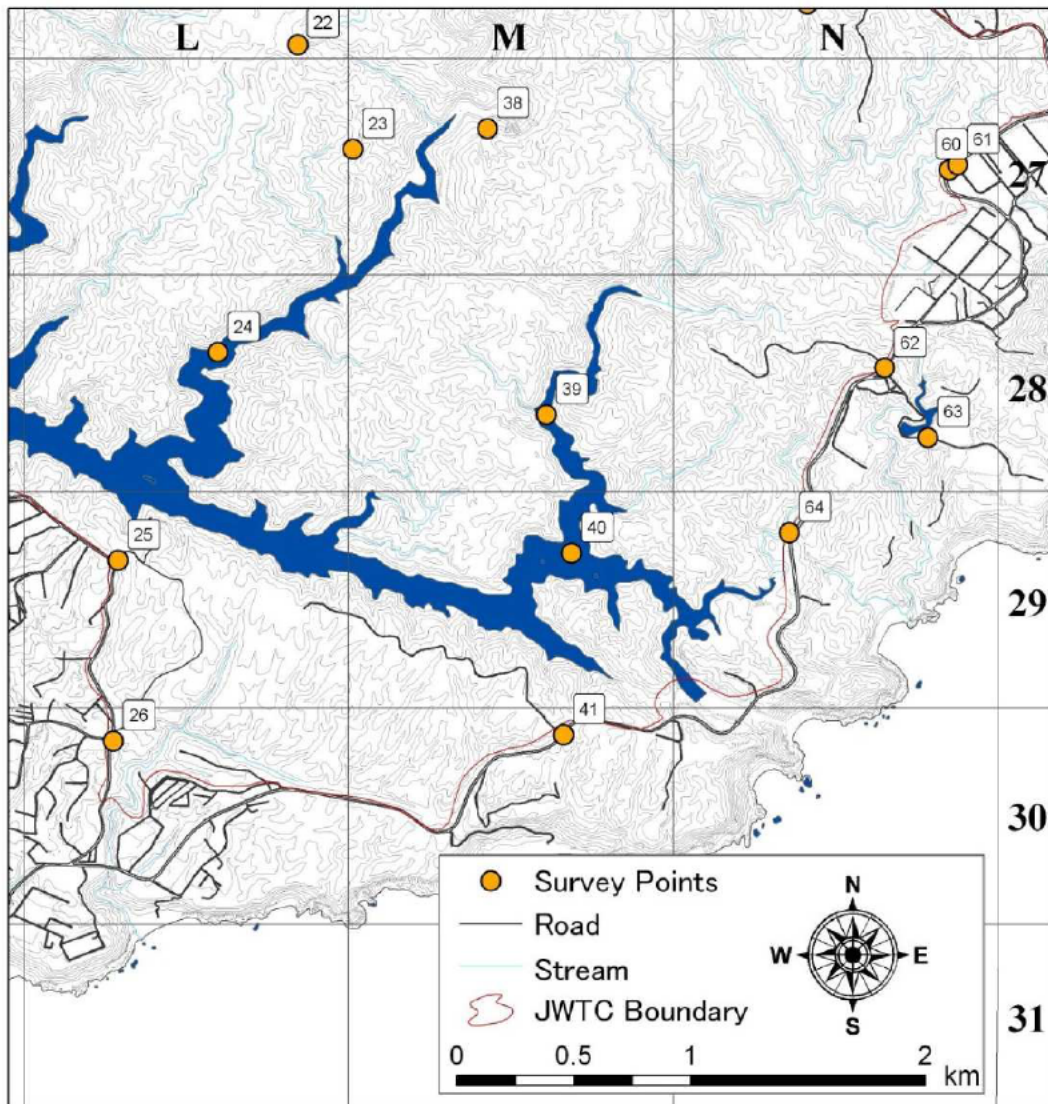
Appendix plate 6 Surveyed points of Map 5



Appendix plate 7 Surveyed points of Map 6



Appendix plate 8 Surveyed points of Map 7



Appendix plate 9 Surveyed points of Map 8

3. Photo Collections



SURVEY ON OKINAWA RAIL

Field Survey

Playback Survey
〈K26〉

Date: November25,2009



SURVEY ON OKINAWA RAIL

Field Survey

Playback Survey
〈L22〉

Date: November25,2009



SURVEY ON OKINAWA RAIL

Field Survey

Playback Survey
〈M28〉

Date: November27,2009



SURVEY ON OKINAWA RAIL

Field Survey

Survey Ground
〈M27〉

Date: November30,2009



SURVEY ON OKINAWA RAIL

Field Survey

Survey Ground
〈L24〉

Date: November30,2009



SURVEY ON OKINAWA RAIL

Field Survey

Survey Ground
〈N22〉

Date: November29,2009



SURVEY ON OKINAWA RAIL

Field Survey

Survey Ground
〈L22〉

Date: November25,2009



SURVEY ON OKINAWA RAIL

Field Survey

Survey Ground
〈N19〉

Date: November27,2009



SURVEY ON OKINAWA RAIL

Field Survey

Survey Ground
〈O21〉

Date: November27,2009



SURVEY ON OKINAWA RAIL

Field Survey

Survey Ground
〈L28〉

Date: November27,2009



SURVEY ON OKINAWA RAIL

Field Survey

Survey Ground
〈M28〉

Date: November27,2009